NVO-136

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RULISON

SITE CLEANUP REPORT

SEPTEMBER 1973

UNITED STATES ATOMIC ENERGY COMMISSION
NEVADA OPERATIONS OFFICE
Las Vegas, Nevada

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1.0 INTRODUCTION

Project Rulison, the second Plowshare experiment cosponsored by industry and government, was designed to determine the potential of using nuclear stimulation for the development of the gas-bearing Mesaverde formation in the Rulison Field in Garfield County, Colorado.

The industrial sponsor for the project was the Austral Oil Company, Inc., Houston, Texas; with the CER Geonuclear Corporation, Las Vegas, Nevada, serving as Program Manager. The Atomic Energy Commission and the Department of the Interior acted jointly on behalf of the government.

Under the technical direction of the Los Alamos Scientific Laboratory, a 43-kt (fission) explosive was detonated on September 10, 1969, at a depth of 2560 meters (8426 feet) in the Piceance Creek Basin. Reentry drilling operations designed to achieve an effective communication with the chimney and fracture system created by the nuclear explosive were begun in April 1970. From the postshot drilling experience it was estimated that the rubble-filled chimney approximated 82 meters (270 feet) in height and 21 meters (70 feet) in radius.

Production testing extended over a seven-month period and included four intermittent flow periods, between October 1970, and April 1971, producing 455 million standard cubic feet (MMSCF) of gas. A bibliography of technical information concerning all phases of Project Rulison is presented in Appendix A; and particular reference is made to the publication entitled "Project Rulison Manager's Report," dated April 1973 (NVO-71).

The purpose of this report is to provide details regarding the cleanup operations as well as to present a brief description of the present standby status of the site. Currently, there are no plans for the decommissioning and final cleanup of the Rulison site, inasmuch as possible sale of the gas to residential, commercial, and industrial users is now being considered by the sponsor.

Cleanup work at the site commenced on July 10, 1972, and was completed July 25, 1972. The purpose was to remove from the site all equipment and materials not needed for possible future gas production. This was accomplished, and the radiological condition of the site was documented. (See Sections 2.0 and 3.0.)

It is expected that the AEC will continue with a long-term hydrological surveillance program; and also will continue to conduct annual site inspections. (See Section 5.0.)

It is currently planned to have a concrete monument placed in the vicinity of the Rulison emplacement well. The following wording is proposed for the plaque to be affixed to the monument:

PROJECT RULISON SITE

No excavation, drilling, and/or removal of subsurface materials to a depth of 12,450 feet is permitted within Lot 11, NE 1/4 SW 1/4, of Section 25, Township 7 South, Range 95 West, 6th Principal Meridian, Garfield County, Colorado, without U.S. Government permission.

U.S. Atomic Energy Commission &
the Department of the Interior

1.1 AEC CLASSIFICATION AND SECURITY INTERESTS

Basic classification guidance for Project Rulison-related activities is contained in the Classification Guide for the Peaceful Application of Nuclear Explosives (CG-PNE-2, dated March 1973), as supplemented by the Project Rulison Classification Guide (dated April 11, 1969).

The only classified interest remaining at the Rulison Site is the nonvolatile radioactive debris in the chimney. This debris is classified Secret, Restricted Data, until analyzed. It is protected by approximately 8000 feet of overburden.

Periodic site inspection and surveillance visits are conducted by Security personnel.

1.2 CURRENT SITE CONDITIONS

The following is a summary description of those Austral-owned facilities remaining onsite as of September 1, 1973: (There is no AEC-owned personal property remaining on the site.)

1. R-E, the Rulison emplacement well, is equipped with high-pressure wellhead equipment and pressure gaging instruments. The wellhead is protected by a metal shed and is enclosed by a 6 foot combination barbed wire and cyclone fence with one locked gate. (Austral has posted "No Trespassing" signs on this fencing.)

2. R-EX, the Rulison exploratory well, which also served as the postdetonation production test well and its attendant cutoff valves (called a Christmas tree) are enclosed with a 5 foot barbed wire fence. The reentry wellhead equipment is configured for further gas production; however, the capability for gas flaring is no longer available.

   The protective fencing enclosing the R-EX wellhead encircles several acres of land utilized during the postdetonation gas production and testing program; and also has one locked gate. (See Figures 1a and 1b.) Those contaminated items remaining onsite are: three 210-barrel liquid (water) holding tanks; and a 3-phase separator which is connected to the R-EX wellhead by a pipeline.

NOTE: WELLHEAD EQUIPMENT, SEPARATOR, DRIP PANS, EFFLUENT TANKS AND TWO METAL BUILDINGS REMAIN ON SITE AS OF AUGUST 1973.

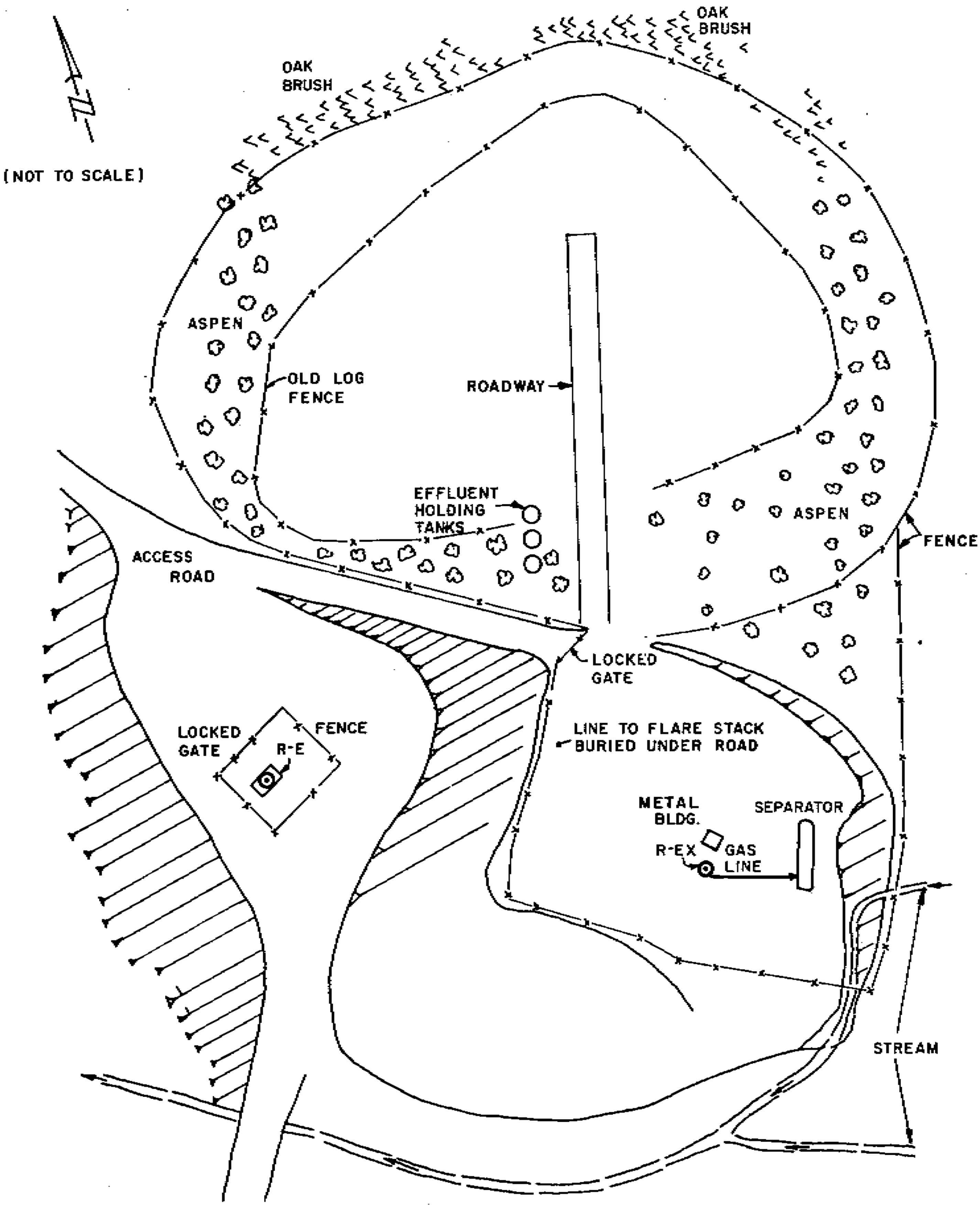

Figure 1a. RULISON SITE AT COMPLETION OF SITE CLEAN-UP.

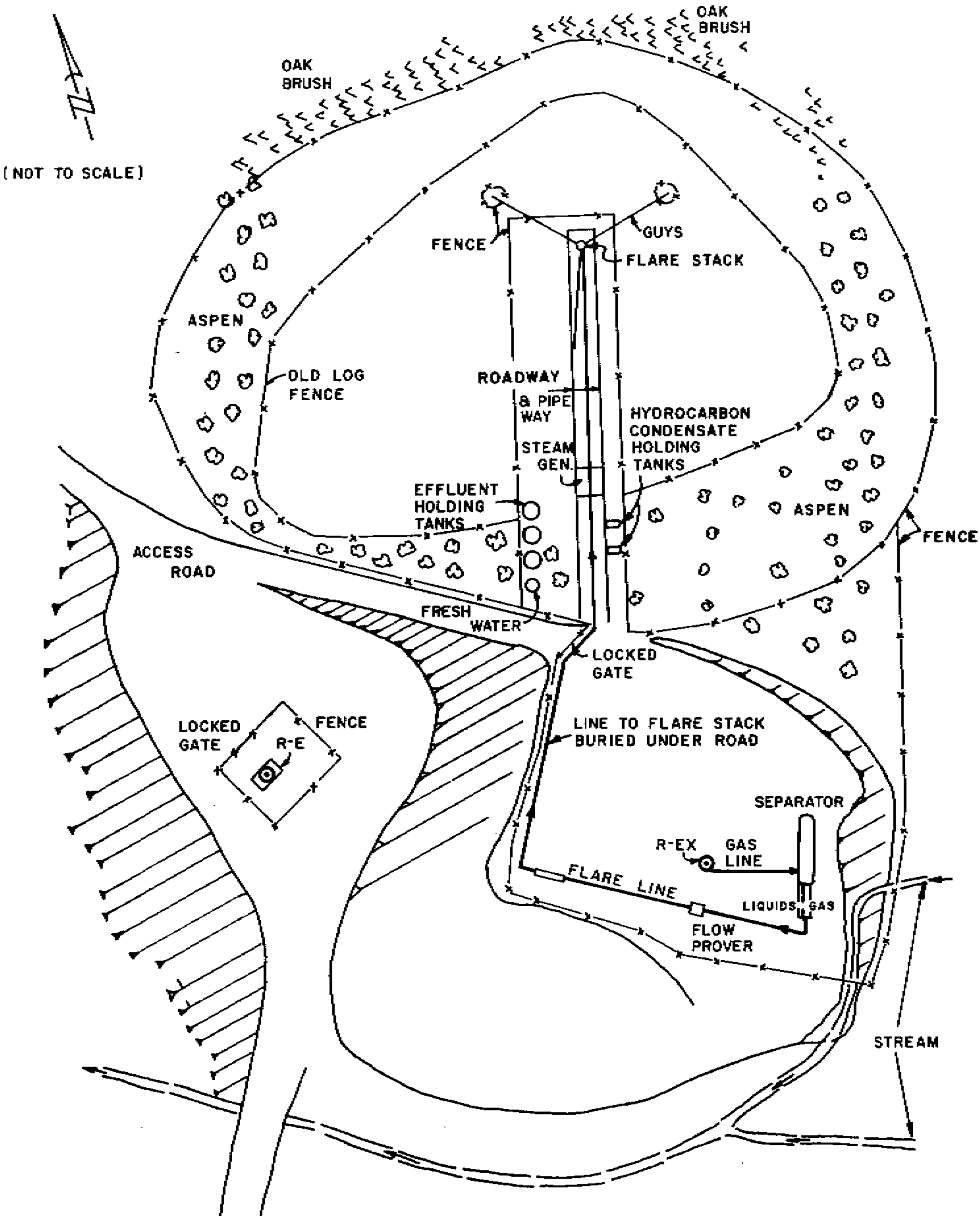

Figure 1b. RULISON SITE AT COMPLETION OF FLARE TESTING.

(Austral also has posted this perimeter fencing with "No Trespassing" signs. In addition, "Radiation Warning" signs have been affixed to those contaminated equipment items that remain onsite and which may be utilized for possible future gas production.)

A tool and instrument shed is in place on the site--near the R-EX wellhead--together with some piping and drip pans which were utilized in the reentry drilling operation.

3. Telephone and electric power lines remain in place.

A large pit which was used for containment of surplus drilling fluids during the emplacement hole drilling operations is separately fenced with 6-foot hog wire fencing topped with three strands of barbed wire; enclosing an area of approximately two acres. The pit, which is located about one-half mile downslope to the northwest, is equipped with a spillway on the downslope side, 6 feet below the crest, and now contains fresh water from surface runoff.

This pit is not under AEC control; it is located in Lot 5 of Section 25. The present owner of the property, Lee Hayward--son of Claude V. Hayward, is retaining the pit for his own use (by a separate agreement directly with Austral).

At some future date, Austral may wish to conduct additional downhole measurements of temperature and pressure. These measurements would be conducted without AEC surveillance since experience has shown that such operations can be carried out with no hazard.

2.0 SITE CLEANUP OPERATION

The site cleanup activities, funded entirely by Austral, took place between July 10, 1972, and July 25, 1972. The purpose of the operation was to remove all equipment and material not needed for possible future use and to ensure site compliance with the radiological safety guides as set forth in Appendix B. The only isotope of interest was tritium; no other radioisotopes, except those naturally occurring, were detected. Radioactively contaminated materials and equipment--if not needed for possible future gas production--were packaged and removed for burial at the Nuclear Engineering Company (NECO) waste facility at Beatty, Nevada.

Eberline Instrument Corporation (EIC) was assigned under Contract AT(26-1)-294 to furnish radiological support for the cleanup of the Project Rulison site. Three EIC employees plus one man from the NV Radiological Operations Division participated. Austral Oil Company provided one supervisor plus a five-man labor crew.

2.1 EQUIPMENT

An AEC mobile radiation measurement trailer was transported to the site. This trailer contained a liquid scintillation system, a gamma spectrometry system, and a gross alpha-beta counting system. It served further as an office and as a central point of operations.

A sample preparation area was improvised in the Rulison reentry wellhead shack.

The following types of portable survey instruments were used:

> Eberline E-400 with HP-177 probe--a low-range beta-gamma detection instrument.
>
> Eberline PRM-4 with HP-210 probe--a pulse rate meter with a probe window of less than 7 mg/cm^2.
>
> Eberline PRM-5 with SPA-2 probe--a pulse rate meter with a 1" x 2" crystal detector.

A supply of supplementary equipment and material such as glassware, tools, plastic containers, and anticontamination clothing was furnished by EIC.

2.2 PERSONNEL MONITORING

All personnel participating in the cleanup wore thermoluminescent dosimeters (TLD's) throughout the operation. Fourteen TLD's were issued, and these were read at EIC's facilities in Santa Fe, New Mexico, subsequent to the cleanup. No exposure was recorded. All dosimetry records were submitted for storage in the AEC dosimetry system at the Nevada Test Site.

Paper anticontamination coveralls were worn by personnel while transferring contaminated liquid among the storage tanks and from the tanks to a NECO tanker truck.

Baseline urine samples were collected prior to initiation of work. Samples were collected again upon completion of the cleanup. These samples were analyzed for tritium down to 10 pCi/ml by liquid scintillation analysis--none contained detectable tritium.

Participants received no measurable radiation exposure due to performance of cleanup work at the site.

2.3 DECONTAMINATION AND DISPOSAL OF EQUIPMENT AND MATERIAL

Holding areas were established to segregate "clean" from contaminated items of equipment and material. A release log was utilized to describe each item and to record its radiological condition. Each item was surveyed with a PRM-4 (HP-210 probe) and swipe tested to check for removable contamination. All items released for unrestricted use had a survey reading of background and a 100 cm^2 swipe count of less than 1000 disintegrations per minute (dpm).

The structures and facilities remaining onsite after completion of production testing are noted in Section 1.2. The general approach was to first survey and swipe the equipment and material that had not been in contact with contaminated liquids or gases, for example, the Western Slope gas line and the clean water supply line. After verifying that these were not contaminated, they were moved to the clean holding area.

The next step was to disassemble pipelines and equipment known to have been in contact with contaminates. Care was taken to drain and contain all liquids obtained from this disassembly operation. Items that could not be economically decontaminated because of fixed lime or rust scale were surveyed and swiped for documentation and were moved to the holding area for contaminated material. Small pipes and solid waste were placed inside large pipes. The ends of pipes serving as containers were closed with welded plates. Outside surfaces were surveyed and swiped to verify that these surfaces were not contaminated.

The old pipe rack drip pan was used as a decontamination pad. Decontamination was accomplished with saturated steam and Steamzall, a TURCO product. The inside areas of pipes were reached with a long steam lance. Items that could be economically decontaminated were moved into the pipe rack drip pan, decontaminated, and then moved into the wellhead drip pan for survey and swipe checking. When decontamination was satisfactory (background survey and less than 1000 dpm/100 cm^2 removable contamination), they were moved to the clean holding area. Steam condensate generated by the decontamination procedure was collected and held in 55-gallon steel drums.

On July 20, 1972, liquids held in the three water storage tanks and the two hydrocarbon storage tanks were pumped into a NECO tanker truck. The water tanks were pumped with a vacuum-type pump until only two to three inches of sludge remained in the bottom of each. This sludge was solidified with five bags of Bentonite per tank. The hydrocarbon tanks were drained completely dry. The outside surfaces of the tanks were not contaminated. They were closed and plugged, posted with appropriate signs, and left in place for possible future use.* The tanker truck shipment cumulated to 3000 gallons of fluid containing a total of 0.69 Ci of tritium.

On July 22, 1972, 32 packages of solid contaminated waste and six 55-gallon drums of liquid were loaded on a NECO flatbed

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*On August 9, 1973, these two 500-gallon hydrocarbon condensate holding tanks were removed from the site for use during the production testing at Project Rio Blanco.

truck. Each drum was contained in a NECO-furnished, Department of Transportation-approved, container known as a "Paper Tiger." The outside surfaces of all containers were not contaminated. This shipment contained an estimated 73 mCi of tritium.

Items of equipment and materials found to be clean, as well as those that had been decontaminated, were removed to the Austral storage yard at Rifle, Colorado. Items in this category included the flare stack and the sections of 2-inch and 6-inch pipe between the north gate and the separator.

Certain items such as the wellhead Christmas tree, the three water tanks and two hydrocarbon tanks, separator, and the wellhead-to-separator gas line were left onsite for possible future use. These items are, or are presumed to be, contaminated internally. In addition, the wire line rig and the dead weight pressure measuring system, also contaminated, were left on the site.

Uncontaminated trash was buried in an on-site trash pit. The drip pans, emplacement well shack, and reentry wellhead shack, all uncontaminated, were left in place for possible further use. Other miscellaneous shacks were torn down and removed pursuant to release procedures.

The AEC trailers were packed for return to EIC's facility at Albuquerque, New Mexico, and all equipment and personnel departed the site on July 25, 1972.

3.0 RADIOLOGICAL SURVEY RESULTS

Concurrent with facility and equipment decontamination and removal, soil, vegetation, water, and air samples were collected and analyzed to determine the distribution and concentration of residual contamination. Concentrations of tritium in soil moisture ranged from not detectable to 47,000 pCi/ml. Concentrations of tritium per weight of soil ranged from not detectable to 20,000 pCi/g.

A total of 11 vegetation samples was collected. An aliquot of moisture from each sample was analyzed for unbound tritium. Concentrations ranged from 4.5 to 170 pCi/ml (H_2O) and from 2.8 to 150 pCi/g (wet sample). Part of each sample was dried and then oxidized to obtain an aliquot containing tritium bound in the sample. Concentrations of this bound tritium ranged from less than 8.3 to 190 pCi/ml (water from oxidation) and from less than 0.8 to 5.3 pCi/g (wet sample).

No tritium was detected in samples of site spring water and site air moisture.

The term "not detectable" as used herein means less than three standard deviations of background, or 1 pCi/ml of the sample.

3.1 SOIL SAMPLING

The soil sampling program was the critical path in the site cleanup plan. Therefore, it was started as early as possible and was given special emphasis throughout the cleanup period.

A square grid of soil sampling points was laid out on magnetic cardinal headings using the site entrance gate post as the zero and primary reference point. Ten- and twenty-foot squares were used depending on the area use history and on the probability of soil contamination. Further, squares were sometimes distorted to sample points of special interest such as storage tanks, pipeline runs, the separator, and drip pan areas or to avoid obstructions such as cement pads. While the flare stack was located on the square grid system, the area around it was sampled on a radial grid referenced to the stack. This radial grid was used because contaminated fallout originated from the stack as a center and because a radial sampling grid was used previously during postflare operations, making a comparison more meaningful. A total of 192 sampling points was located. (See Figures 2 and 3.) Most of these points were sampled at 1- and 12-inch depths. Fourteen points were sampled at 1- 12-, 24-, and 48-inch depths. Two points were sampled at multiple depths to 96 and 132 inches, respectively. A few were sampled at selected depths for various reasons. A total of 426 soil samples was collected for tritium analysis.

The depth increment for soil samples taken was 1 inch; i.e., the 1-inch sample was from the surface to 1 inch, the 12-inch sample was from 11 to 12 inches, etc. Soil samples were collected in standard 16-ounce cottage cheese containers that held 24 to 27 cubic inches of sample. Therefore, with a depth increment of 1 inch, the sampled soil area for each sample was from 4.9 to 5.2 inches square. At undisturbed and uncompacted sampling locations, an earth auger was used to bore holes up to 4 feet deep. For sampling at greater depths, and at disturbed and compacted locations, a powered backhoe was used to dig required holes. After these holes were cleaned out, the samples were taken from their side walls at measured depths. Access to sampling points under waste water storage tanks was attained by drilling horizontally under each tank from a trench at its perimeter. Access to sampling points under drip pans was attained by cutting through the pan or by moving it to one side.

Each sample was weighed wet, as collected, and was then dried in an electric oven for 15 hours at 180 degrees centigrade. After drying, the sample was again weighed. Wet and dry weights were recorded for each sample and the percentages of moisture were calculated. Where possible, a 5-ml aliquot of soil moisture was distilled from each sample. The aliquots were analyzed by liquid scintillation for tritium concentration in pCi/ml. From this, the concentration in pCi/g was calculated. Results of these analyses are shown in Table 1, Appendix C.

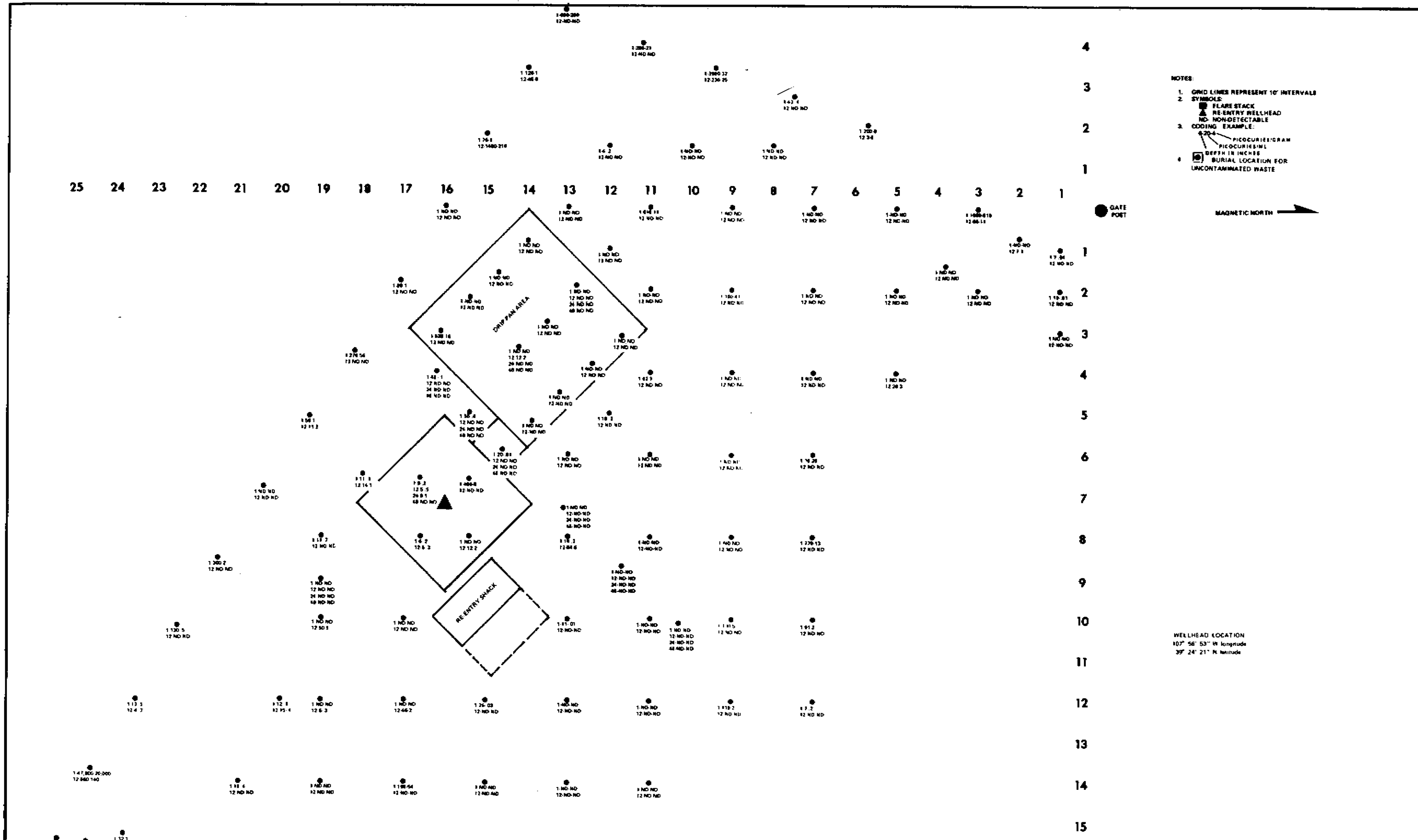
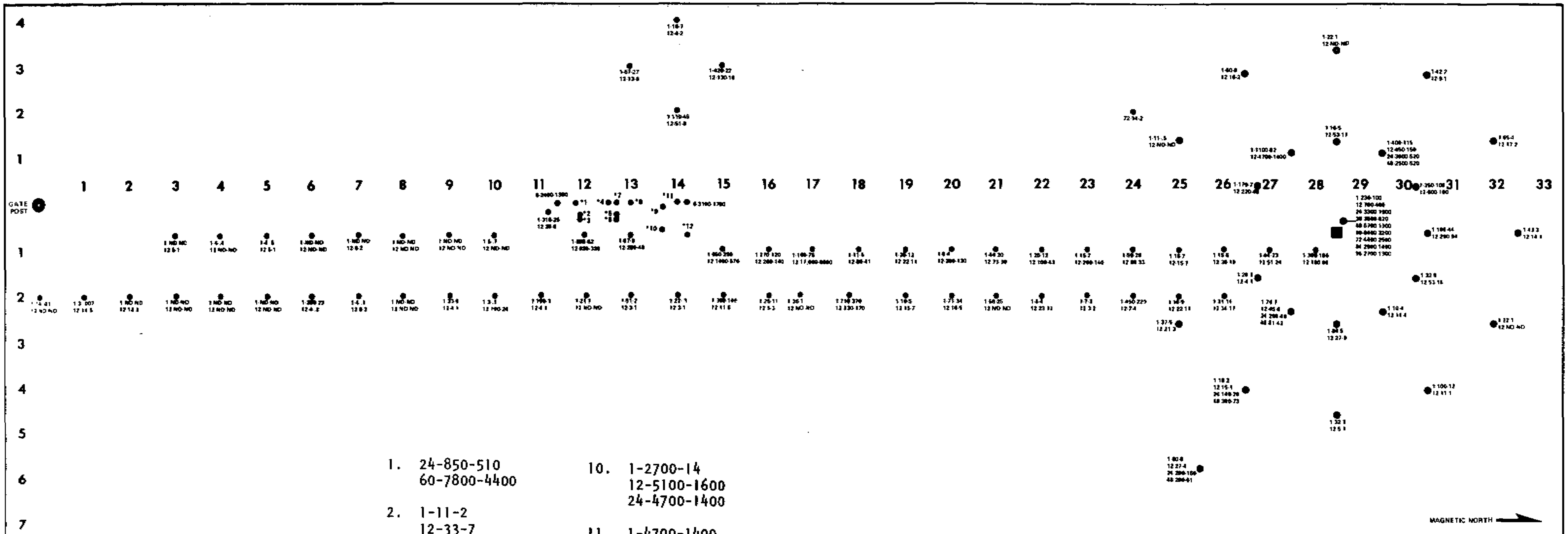


FIGURE. 2

SOIL SAMPLE LOCATIONS TAKEN AT TIME OF SITE CLEANUP



1. 24-850-510
   60-7800-4400
2. 1-11-2
   12-33-7
3. 1-110-24
   12-93-22
4. 1-300-34
   12-12-15
5. 1-44-10
   12-ND-ND
6. 1-21-8
   12-11-5
7. 6-150-81
8. 12-73-41
   60-51-24
9. 1-10,000-1400
   12-20,000-5600
   24-21,000-5800
10. 1-2700-14
    12-5100-1600
    24-4700-1400
11. 1-4700-1400
    12-3300-1800
12. 1-8600-1500
    12-29,000-6500
    24-35,000-11,000
    36-34,000-19,000
    48-27,000-7300
    60-26,000-14,000
    72-18,000-9600
    96-8000-9600
    108-9700-2300
    120-5600-1400
    132-3300-600

FIGURE. 3

SOIL SAMPLE LOCATIONS TAKEN
AT TIME OF SITE CLEANUP

Upon completion of the last production test on April 23, 1971, soil on arcs around the flare stack was sampled and analyzed for tritium. The results of this sampling program are provided in Table 2, Appendix C, and sample locations are shown on Figures 4 and 5. These data are included in this report to permit comparison where the same locations were sampled during site cleanup.

Eight randomly located soil samples were collected for pulse height analysis by gamma spectrometry. No radioisotopes other than those naturally occurring were detected.

3.2 VEGETATION SAMPLING

A vegetation sample was taken at each cardinal point on a 500-foot and a 1000-foot arc around the flare stack. Additional vegetation samples were collected at site grid point N-14, W-2, and stack grid points 030°, 5' and 120°, 40'. These samples were collected because of a leak from a water storage tank, the close proximity to the flare stack, and the area of highest concentration indicated by the postflare sampling, respectively.

Vegetation samples were analyzed at EIC's facilities in Albuquerque after the cleanup operation. Each sample was weighed wet and dry. An aliquot of moisture was distilled from the sample. An aliquot of dry sample was oxidized and condensed to obtain the bound tritium. The results of these analyses are shown in Table 3, Appendix C.

3.3 AIR SAMPLING

Filtered air samples were taken for three days, a dry ice freeze trap was run for two days, and samples were collected daily from both. The sampling point was on the drillback pad approximately 95 feet from the wellhead on a bearing of 005 degrees. In addition, a freeze-out sample was collected from the steam used in decontamination. No radioactivity was detected in the filtered air samples and no tritium was detected in the freeze-out air moisture samples.

3.4 WATER SAMPLING

Prior to completion of the cleanup, water samples were taken from each of two local springs at the site. One was located just off of the southeast corner of the drillback pad, the other was on the upper side of the road about 300 yards downhill from the pad. Both samples were analyzed by liquid scintillation. No tritium was detected.

3.5 SLUDGE SAMPLING

A sample of the sludge left in the bottom of the three water holding tanks was taken before the solidifying agent (Bentonite)

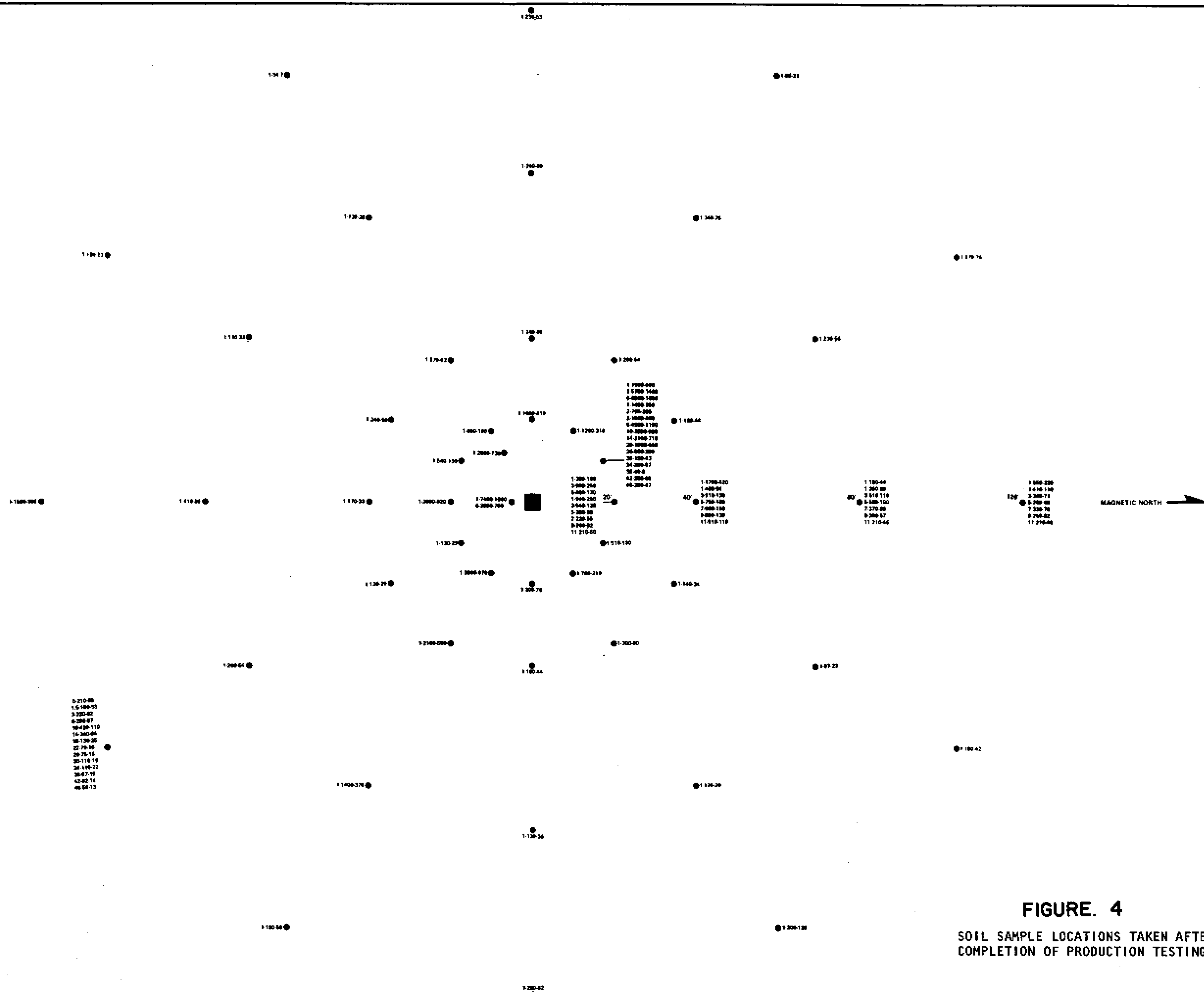


FIGURE. 4

SOIL SAMPLE LOCATIONS TAKEN AFTER COMPLETION OF PRODUCTION TESTING

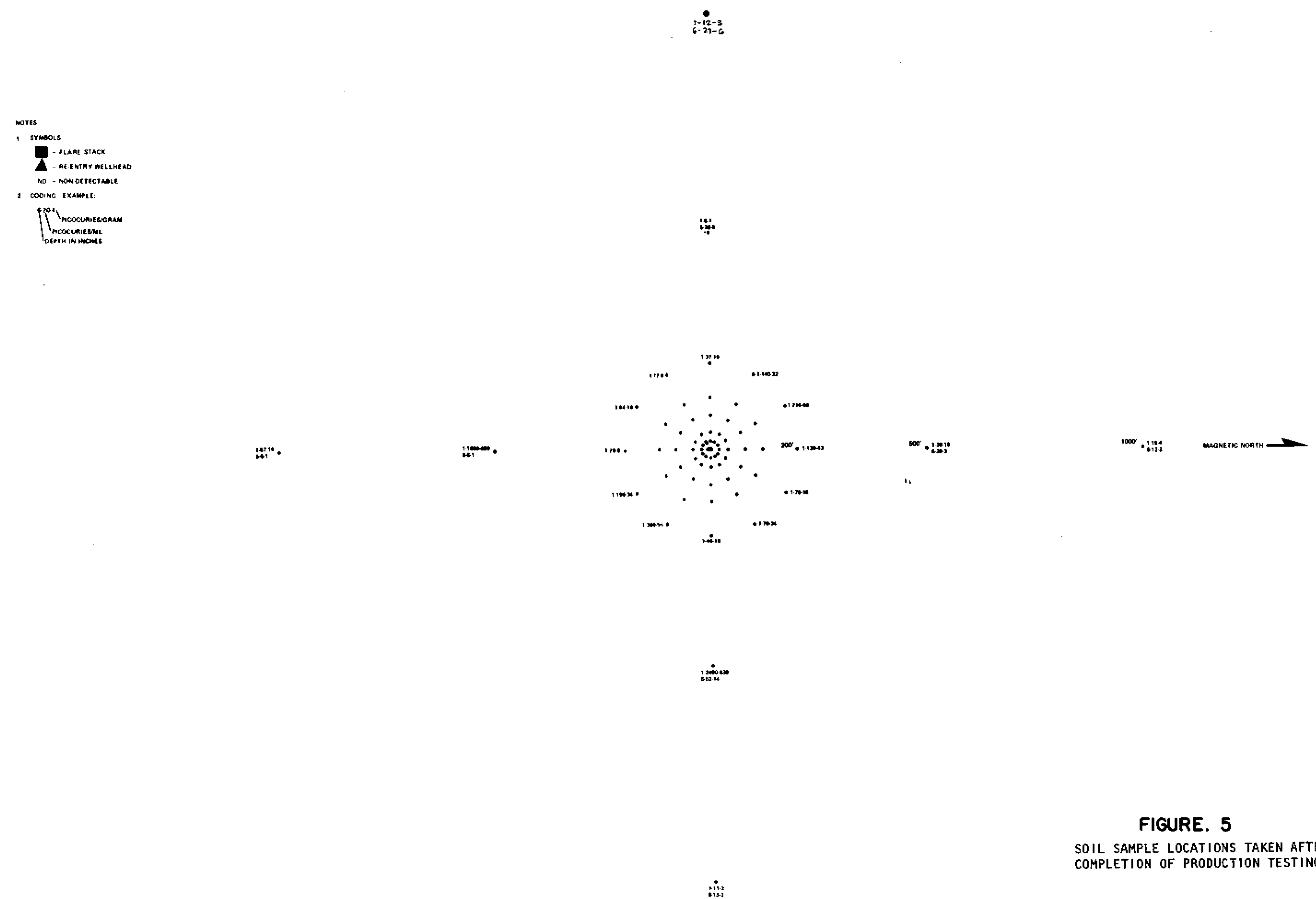


FIGURE. 5

SOIL SAMPLE LOCATIONS TAKEN AFTER COMPLETION OF PRODUCTION TESTING was added. This sample was analyzed for tritium by EIC in Albuquerque after the cleanup. Because the sample was in hydrocarbon form, it was oxidized and its condensed water vapor was analyzed by liquid scintillation. The tritium concentration was 15,000 pCi/g of sludge. Total volume left onsite in the tanks was not more than 441 gallons. Assuming a density of 1.2, the total amount of tritium in solidified sludge that remains stored at the site is not more than 0.03 Ci.

4.0 LAND USE AND CONTROL

Austral Oil Company's lease holdings in the Rulison field--a part of the Piceance Basin in west-central Colorado--comprise approximately 60,000 acres of land (see Figure 6). The boundary of this approved federal unit lies south of the Colorado River and extends from an elevation of about 5200 feet, near the river, up the slopes of Battlement Mesa to an elevation of over 10,000 feet.

The project site is located in the southern part of the unit, in Garfield County, about six miles southeast of the town of Grand Valley. The project site is on the upper reaches of Battlement Creek on the north slope of Battlement Mesa. The elevation of the emplacement well (R-E) is 8154 feet above sea level; and the valley is open to the north-northwest and is bound on the other three sides by steep slopes rising above 9600 feet. The region is covered with grass, Engleman spruce, fir, cedar, and aspen trees on the upland; and by sagebrush and range grass in the lower elevations.

The location for the Rulison experiment is Lot 11 NE 1/4 SW 1/4 in Section 25, Township 7 South, Range 95 West, 6th Principal Meridian, Garfield County, Colorado. The surface ground zero (SGZ) area is served by a 16-foot wide graveled road that connects with the county-maintained road system.

The population of the immediate Rulison area is confined principally to the valleys of the Colorado River, Plateau Creek--a tributary to the Colorado River, and adjacent mesa lands. About 220 persons live between 3.5 and 5 miles from SGZ and about 1500 additional persons live between 5 and 10 miles from the SGZ. No permanent habitation exists closer than 3.5 miles to the SGZ.

The economic base of the nearby area is provided by the raising of livestock and the cultivation of orchards and livestock feeds.

4.1 SURFACE RIGHTS

By means of an agreement (deed) executed by Claude V. Hayward on February 23, 1969, Mr. Hayward, the owner, granted to the government the sole and exclusive right to regulate and control access

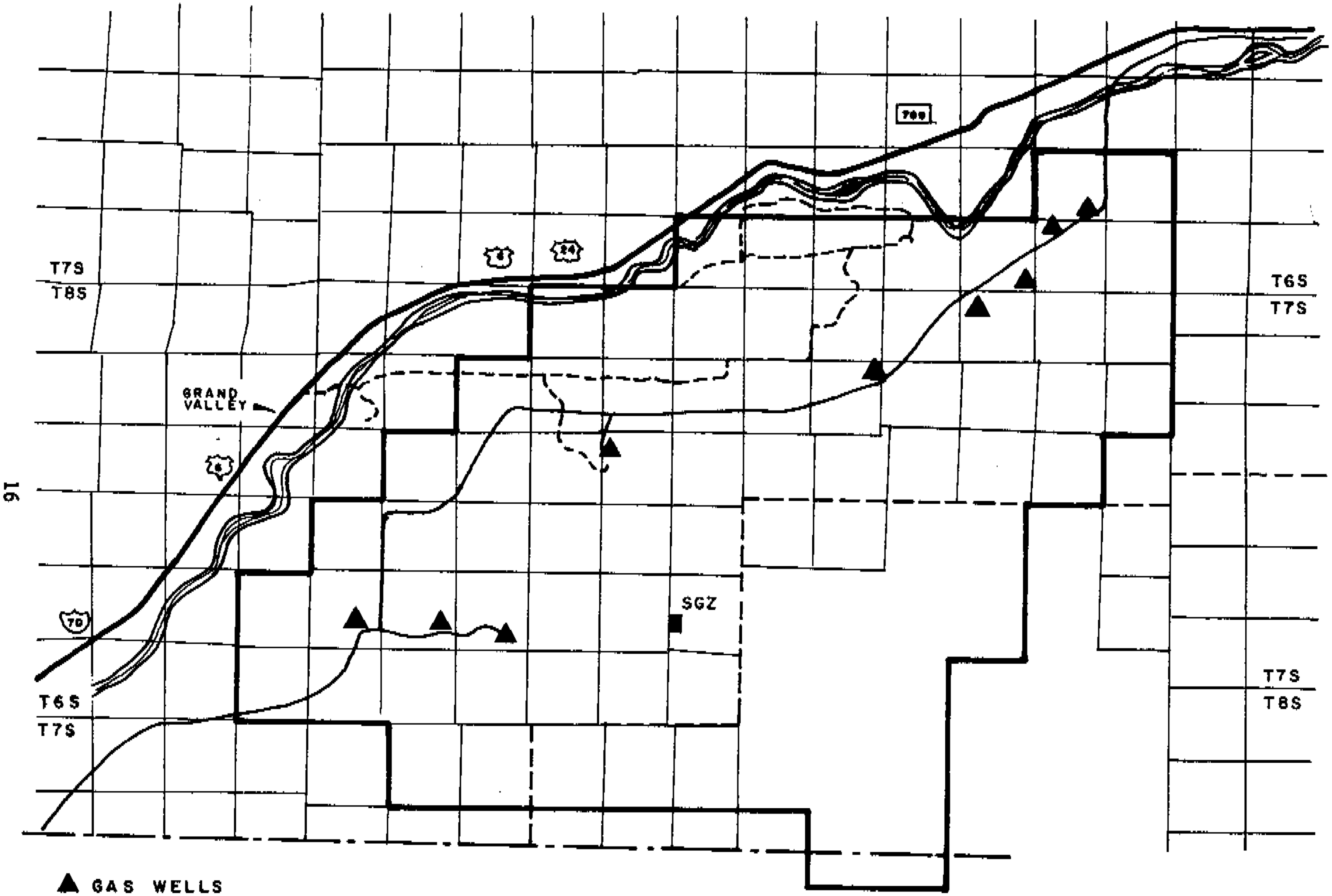


Figure 6. PROJECT RULISON DRILLING UNIT.

to and use of the surface of Lot 11 NE 1/4 SW 1/4 of Section 25, Township 7 South, Range 95 West, 6th Principal Meridian, Garfield County, Colorado. (This amounts to 40 acres of land area.)

This agreement continues in effect for a period of five years, with the AEC having the option to renew the government's rights for successive five-year periods by notifying Mr. Hayward in writing not less than 90 days prior to the end of each five-year period (i.e., November 22, 1973) and paying a sum of $350 for each successive renewal.

The AEC has the prerogative to release to Mr. Hayward (at any time) the surface rights of the above-described land (or any part thereof) which the AEC deems as no longer needed for security, public health, and safety reasons.

4.2 SUBSURFACE RIGHTS

Under the terms and conditions of the Rulison contract, AT(26-1)-429, Austral Oil Company, Inc., granted to the government its subsurface operating rights . . . from the surface of the earth to a depth of 500 feet below the base of the Mesaverde formation as to Lot 11 NE 1/4 SW 1/4 of Section 25, Township 7 South, Range 95 West, 6th Principal Meridian, Garfield County, Colorado.

Should the Rulison contract be terminated, then some substitute arrangement must be entered into with Austral so long as Austral retains its subsurface oil and gas rights and a need to control access to the underground area is required by the government for security, public health, and/or safety reasons.

However, should Austral transfer its subsurface oil and gas rights, then a subsequent agreement would have to be reached with the new owner of such subsurface rights; or the government would have to consider exercising its right of condemnation.

4.3 REAL ESTATE POTENTIAL

The Rulison site is not hazardous to wildlife and is not restricted from normal ranch usage--except for the three small fenced areas described in Section 1.2. No plans for other use of the land surface have been identified to NV.

With regard to the recovery of underground mineral resources, the site appears to have little economic or commercial importance other than the potential development of the natural gas resources by Austral.

In view of the above, and inasmuch as no population centers would appear to be affected, no plans have been made by NV for the limited release of the site prior to 1989 at the earliest; i.e., a minimum of 20 years following the Rulison detonation.

5.0 PRE- AND POSTSHOT HYDROLOGIC INVESTIGATIONS

5.0.1 Teledyne Isotopes (TI), Palo Alto Laboratories made preshot investigations of the hydrologic environment at the Project Rulison site. TI, using field data accumulated by the U.S. Geological Survey, predicted the extent of groundwater contamination for the Rulison event. The Rulison explosive was emplaced near the base of the Mesaverde Formation at a depth of 8426 feet. This depth of burial was considerably greater than that required for explosion containment under normal testing purposes. Essentially all of the explosion-produced radionuclides were contained within the Mesaverde formation. Groundwater in this formation was estimated to move at a maximum rate of one foot per day, the most probable rate being closer to zero. Assuming the one foot per day rate of flow, TI predicted that tritium, the radionuclide of primary interest, would move less than one mile before decaying (along with dispersion) to a concentration less than the established Radiation Concentration Guide for drinking water.

5.0.2 The U.S. Geological Survey conducted a preshot inventory of wells and springs in the Rulison area between March 20, 1969, and May 25, 1969. The purpose of the inventory was to document the condition of wells and springs and to collect water samples for chemical and radiochemical analysis. All known wells within a 10-kilometer radius of the Rulison emplacement hole were inventoried. Selected wells and springs were inventoried within a 10- to 20-mile radius. A total of 29 samples were selected for background radiochemical analysis. Subsequently, a sampling network of 21 stations was established to provide the basis of evaluating postshot changes in radionuclide concentrations.

The preestablished hydrologic network of 21 stations initiated for radiochemical analysis was sampled 10 days after the Rulison event. Analysis confirmed that the event was not responsible for any increases in radioactivity in surface or groundwater supplies.

5.1 LONG-TERM RADIOLOGICAL SURVEILLANCE

5.1.1 Hydrology

The Hydrologic Program Advisory Group (HPAG) reviewed the hydrologic monitoring program proposed for the Rulison site at their December 12, 1971, meeting. They found the program adequate and recommended its immediate initiation. EPA/NERC, Las Vegas, was selected to conduct the monitoring program.

The sampling points, as shown in Figure 7, are listed below:

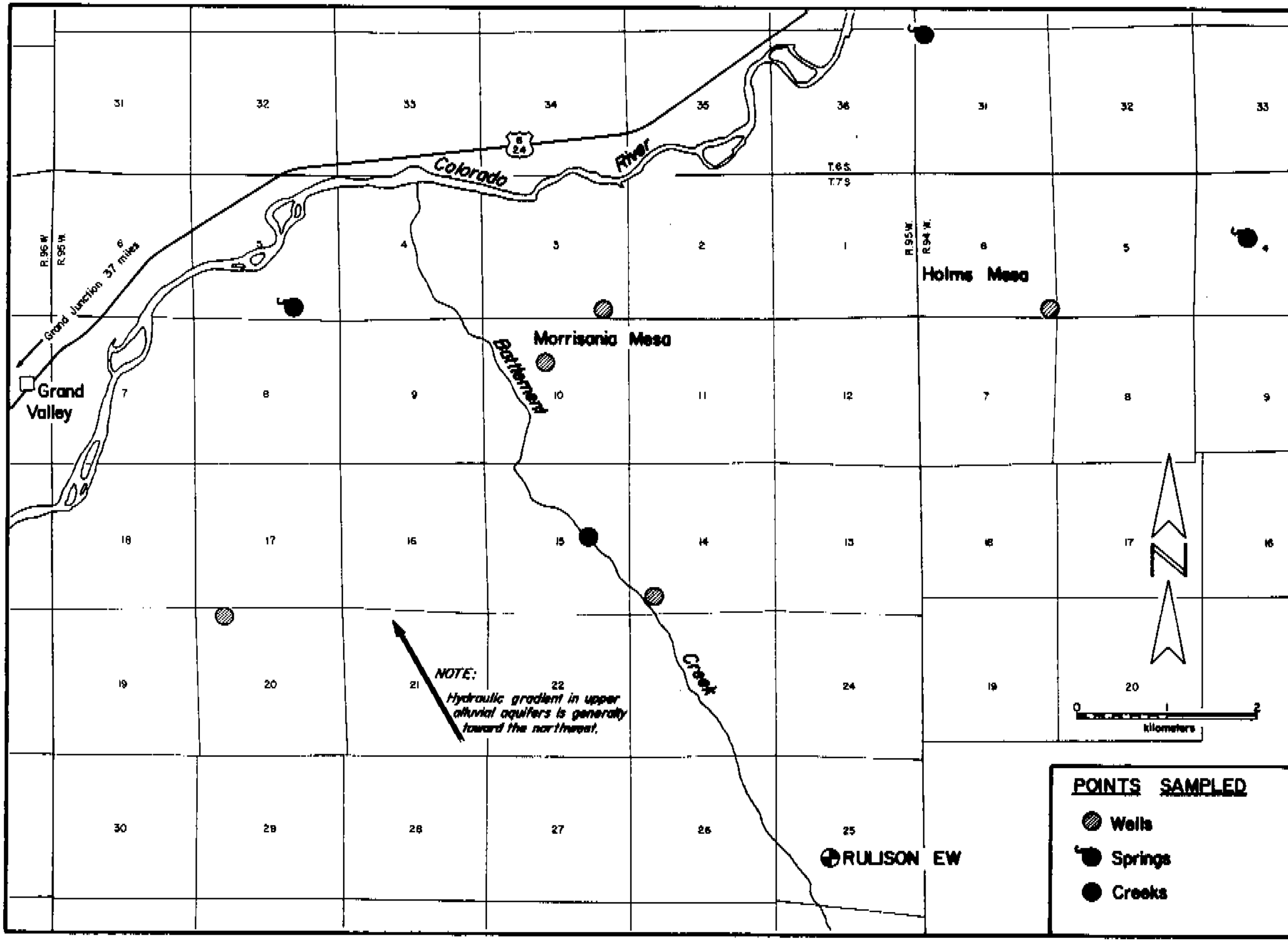


FIGURE 7. HYDROLOGIC SAMPLING POINTS - RULISON EVENT

a. Battlement Creek at the nearest down gradient accessible location in T7S, R95W, Sec. 15 SE 1/4 NE 1/4.

b. Two private wells in alluvium on Morrisania Mesa.

   Locations:

   (1) T7S, R95W, Sec. 10 NE 1/4 SE 1/4 NW 1/4

   (2) T7S, R95W, Sec. 3 SW 1/4 SE 1/4 SE 1/4

c. Water supply springs for Grand Valley located at:

   T7S, R95W, Sec. 5, SE 1/4 SW 1/4 SE 1/4

d. Two springs and two wells located close to surface ground zero:

   (1) Well: T7S, R95W, Sec. 20 NE 1/4 NW 1/4 NW 1/4

   (2) Well: T7S, R95W, Sec. 6 SE 1/4 SE 1/4 SE 1/4

   (3) Spring: T7S, R94W, Sec. 4 SW 1/4 SE 1/4 NW 1/4

   (4) Spring: T6S, R94W, Sec. 31 NW 1/4 NW 1/4 NW 1/4

e. The Austral well located in T7S, R95W, Sec. 14 SW 1/4 SW 1/4.

Flexibility will remain in the program in the selection for monitoring of private domestic water sources. Such selection is to be based upon proximity to the test area and on the potential for future claims of damage.

Sample Analysis. Unless otherwise specified, all samples will be analyzed for tritium using a technique with a lower level of 150 tritium units.* All samples will be analyzed for gross alpha and gross beta radioactivity and will be given a gamma spectral scan. Gross chemistry analyses, comparable to the USGS chemical water quality analyses, are to be performed on all samples collected on the initial sample run. Based on the results of these analyses, suspect samples will be analyzed for appropriate naturally occurring and man-made isotopes. Splits of each sample collected will be retained for this purpose until it is demonstrated that the need to retain them does not exist.

Frequency. Each water source is to be sampled once per year, preferably in the early spring, weather permitting.

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*One tritium unit equals 3.3 pCi/ℓ

Reports. The first of the annual reports which is to be prepared will contain but not be limited to the following:

a. A description of the basic hydrologic system.

b. Pertinent historic data including prediction of groundwater contamination and event effects.

c. Description of sampling network.

d. Results.

e. Explanation of results.

f. Evaluation of the program.

g. Suggested modifications for program improvements.

Subsequent annual reports need only address items number c through g unless data are obtained which changes the basic hydrologic concepts.

Duration. The monitoring program is to continue until, based on the results, a decision is made to terminate monitoring for any or all of the water sources.

5.1.2 Bioenvironment

No need for monitoring the bioenvironment of this site has been demonstrated. Therefore, until such time as the monitoring of surface or groundwater indicates a reason for collecting and analyzing samples of the plant and/or animal species of the area, no collection will be made.

5.1.3 Land Surface and Soils

No need for radiation monitoring instrument surveys or analysis of soil samples has been demonstrated. Therefore, until such time as the monitoring of surface or groundwater indicates a reason for these types of surveillance, none will be made.

5.2 LONG-TERM SEISMOLOGICAL SURVEILLANCE

No need for seismological monitoring of this site for event-induced modifications in the regional or local seismicity pattern has been identified.

APPENDIX A

APPENDIX A

SCIENTIFIC AND TECHNICAL INFORMATION

I. Listed below--in Open File Designator sequence--are all of those publications concerning Project Rulison that have been placed in the Plowshare Open Files by the Nevada Operations Office. In addition to being readily available for purchase through the National Technical Information Service, these publications are available for public inspection in full-size copy at the following three locations:

U.S. Bureau of Mines
Bartlesville Petroleum
Research Center
Virginia and Cudahy Streets
Bartlesville, OK 74003

U.S. Bureau of Mines
Office of Mineral Resource
Evaluation Library, Bldg. 20
Denver Federal Center
Denver, CO 80225

U.S. Atomic Energy Commission
Nevada Operations Office
2753 South Highland Drive
Las Vegas, NV 89102

PNE-R-1	Project Rulison: A Government-Industry Natural Gas Production Stimulation Experiment Using a Nuclear Explosive. May 1, 1969 (NV).
PNE-R-2	Geology and Hydrology of the Project Rulison Exploratory Hole, Garfield County, Colorado. April 4, 1969 (USGS) (USGS-474-16).
PNE-R-3	Pre-Event Bioenvironmental Safety Survey and Evaluation: Project Rulison. July 28, 1969 (BMI).
PNE-R-4	Effects Evaluation for Project Rulison. June 1969 (NV) (NVO-43 Final).
PNE-R-5	Predictions of Seismic Motion and Close-In Effects: Rulison Event. August 1969 (ERC) (NVO-1163-180).
PNE-R-6	Records of Selected Wells and Springs in the Rulison Project Area, Garfield and Mesa Counties, Colorado. August 1969 (USGS) (USGS-474-40).
PNE-R-7	Project Rulison--Site Evaluation Pre-Shot R-Ex Well Test Data. October 20, 1969 (Austral Oil Co., Inc.) (CER).
PNE-R-8	Emplacement and Cementing of Hole 25-95A (Emplacement Hole) Hayward Well in Garfield County, Colorado. 1969 (Austral Oil Co., Inc.).

PNE-R-9	Radioactivity in the Hydrologic Environment: Project Rulison Final Pre-Shot Report. August 13, 1969 (Isotopes, Inc.) (NVO-1229-108 Final).
PNE-R-10	Project Rulison: Planning Directive. May 1969 (NV).
PNE-R-11	Project Rulison: Definition Plan. March 26, 1969 (CER).
PNE-R-12	Project Rulison Feasibility Study. July 1966 (Austral Oil Co., Inc.) (CER).
PNE-R-13	Project Rulison: Post-Shot Plans and Evaluations. December 1969 (NV) (NVO-61).
PNE-R-14	Off-Site Radiological Safety and Resident Evacuation Program for Project Rulison (Detonation Phase). January 1970 (USPHS) (SWRHL-94r).
PNE-R-15	Chemical and Radiochemical Analyses of Water from Streams, Reservoirs, Wells, and Springs in the Rulison Project Area, Garfield and Mesa Counties, Colorado. January 1970 (USGS) (USGS-474-67).
PNE-R-16	Observed Seismic Data: Rulison Event. November 14, 1969 (ERC) (NVO-1163-197).
PNE-R-17	Structural Effects of the Rulison Event. December 1969 (JAB) (JAB-99-76).
PNE-R-18	Seismic Motions from Project Rulison. January 1970 (ERC) (CONF-700101-10).
PNE-R-19	Project Rulison: A Preliminary Report. 1970 (Austral Oil Co., Inc.) (CER).
PNE-R-20	Economics of Nuclear Gas Stimulation. 1970 (Austral Oil Co., Inc.) (CER) (CONF-700101-8).
PNE-R-21	The Effects of the Rulison Event on Buildings and Other Surface Structures. January 14, 1970 (JAB) (CONF-700101-9).
PNE-R-22	Radioactivity in Water--Project Rulison. February 1970 (Isotopes, Inc.) (NVO-1229-131).
PNE-R-23	Rulison Seismic Effects. February 16, 1970 (C&GS) (CGS-746-2).
PNE-R-24	Geohydrology--Project Rulison, Garfield County, Colorado, with a Section on Aquifer Response. March 1970 (USGS) (USGS-474-68).

PNE-R-25 Post-Event Bioenvironmental Safety Aspects: Project Rulison. January 6, 1970 (BMI) (BMI-171-201).

PNE-R-26 Weather Predictions and Surface Radiation Estimates for the Rulison Event: Final Report. January 1970 (EIC) (ARLV-351-4).

PNE-R-27 Analysis of Ground Motions and Close-In Physical Effects, Rulison Event. April 1970 (ERC) (NVO-1163-206).

PNE-R-28 Dynamic and Static Response of the Government Oil Shale Mine at Rifle, Colorado, to the Rulison Event. February 2, 1970 (USBM) (USBM-1001).

PNE-R-29 Rulison Court Decision Concerned with Postshot Flaring Program. March 19, 1970 (District Court U.S.).

PNE-R-30 Harvey Gap Dam Safety Study. May 1969 (Woodward-Clyde & Associates) (JAB-99-63).

PNE-R-31 Project Rulison: CER Geonuclear Corporation's Participation in the Safety Program. July 28, 1970 (Austral Oil Co., Inc.).

PNE-R-32 Seismic Activity in September 1969 Near the Rulison Nuclear Test Site. June 15, 1970 (C&GS) (CGS-746-5).

PNE-R-33 Assessment of Potential Biological Hazards from Project Rulison. December 18, 1969 (UCRL) (UCRL-50791).

PNE-R-34 Public Health Evaluation Project Rulison (Production Testing). May 1970 (USPHS) (SWRHL-96r).

PNE-R-35 On-Site Radiological Safety Report for the Period April 21, 1969 to December 31, 1969. (EIC) (NVO-294-4).

PNE-R-36 Some Seismic Results of the U.S. Gasbuggy and Rulison Underground Nuclear Explosions. 1970 (United Kingdom Atomic Energy Authority) (PNE-G-66) (AWRE-046/70).

PNE-R-37 Sandstone Continuity in the Mesa Verde Formation, Rulison Field Area, N.W. Colorado. 1970 (AIME).

PNE-R-38 Description and Specifications of the Rulison Christmas Tree Installed on the R-EX Well. July 1970 (Austral Oil Co., Inc.).

PNE-R-39 Mine and Well Effects Evaluation for Project Rulison. March 1970 (USBM) (USBM-1002).

PNE-R-40 Methods to Predict Ground Motions from Future Underground Nuclear Detonations in the Piceance Creek Basin, Colorado. January 1970 (ERC) (NVO-1163-TM-18).

PNE-R-41 Project Rulison Yield Escalation Report. (CER) (In Preparation).

PNE-R-42 Radiochemical Analyses of Water from Selected Streams, Wells, Springs, and Precipitation Collected Prior to Reentry Drilling, Project Rulison. 1971 (USGS) (USGS-474-83).

PNE-R-43 Project Rulison: Preshot Investigations and Structural Hazard Evaluations. August 1961 (JAB) (JAB-99-61).

PNE-R-44 Gas Analysis Results for Project Rulison Calibration Flaring Samples. January 7, 1971 (LRL) (UCRL-50986).

PNE-R-45 Project Rulison-Postshot Investigations-Summary of Reentry Operations. January 1971 (Austral Oil Co., Inc.).

PNE-R-46 Structural Response Studies for Project Rulison. February 1971 (JAB) (JAB-99-78).

PNE-R-47 Motion of Rifle Gap Dam, Rifle, Colorado: Project Rulison Underground Nuclear Detonation. January 1970 (U.S. Army Engineers--Waterways Experiment Station) (Miscellaneous Paper S-70-1).

PNE-R-48 Radiochemical Analyses of Water from Selected Streams, Wells, Springs, and Precipitation Collected During Reentry Drilling, Project Rulison. 1971 (USGS) (USGS-474-101).

PNE-R-49 Radiochemical Analyses of Water Samples from Selected Streams and Precipitation Collected in Connection with Calibration Test Flaring of Gas from Test Well, August 15-October 13, 1970, Project Rulison. 1971 (USGS) (USGS-474-107).

PNE-R-50 Radiochemical Analyses of Water Samples from Selected Streams and Precipitation Collected October 23-November 9, 1970, in Conjunction with the First Production Test Flaring of Gas from Test Well, Project Rulison. 1971 (USGS) (USGS-474-108).

PNE-R-51 Rulison Ground Motions Recorded at the TOSCO Mine and Tower Stations. July 30, 1971 (ERC).

PNE-R-52 Project Rulison Postshot Well Test Data. nd (Austral Oil Co., Inc.).

PNE-R-53 Environmental Aspects of Natural Gas Stimulation Experiments with Nuclear Devices. August 27, 1971 (LRL) (UCRL-73429).

PNE-R-54 Statistical Correlation of Observed Ground Motion with Low-Rise Building Damage: Project Rulison. September 1971 (JAB) (JAB-99-87).

PNE-R-55 Project Rulison-Summary of Results and Analysis. October 1971 (Austral Oil Co., Inc.).

PNE-R-56 Radiochemical Analyses of Water from Selected Streams and Precipitation Collected Immediately Before and After the Second Production Test Flaring-Project Rulison. 1971 (USGS) (USGS-474-122).

PNE-R-57 Project Rulison--Final Operational Radioactivity Report Production Tests. February 1972 (NV) (NVO-112).

PNE-R-58 Gas Analysis Results for Project Rulison Production Testing Samples. November 29, 1971 (LLL) (UCRL-51153).

PNE-R-59 Project Rulison Summary Report, Post-Shot Activities and Programs. April 1972 (Austral Oil Co., Inc.).

PNE-R-60 Project Rulison Final Report--Phase II. December 28, 1972 (CER).

PNE-R-61 Off-Site Radiological Safety Program for Project Rulison Re-entry Portion of Phase III. November 1972 (NERC) (NERC-LV-539-14).

PNE-R-62 Statistical Correlation of Observed Ground Motion with Low-Rise Building Component Damage: Project Rulison. January 1973 (JAB) (JAB-99-93).

PNE-R-63 Project Rulison Manager's Report. April 1973 (NV) (NVO-71).

II. Raw monitoring measurements and other production testing information for Project Rulison are also available for inspection at the open file locations listed above. Included in these special collections are the following:

A. Production Test Data

1. Flowing surface pressures and temperatures.
2. Flowing downhole temperatures and pressures.
3. Downhole shut-in pressures and temperatures.
4. Surface shut-in pressures.
5. Gas flow rate.
6. Gas produced.

7. Condensate produced.
8. Water produced.
9. Gas gravity.
10. Gas sample analyses for chemical composition and radioactivity concentrations.

B. On-Site Rad-Safety Data

1. Tritium and krypton concentrations in gas flowing out flare stack.
2. Particulate samples from the gas stream.
3. Gross gamma radioactivity in the flow line.
4. Radioactivity in water and condensate from the gas stream.
5. Air samples for alpha, beta, and gross gamma radiation.
6. Thirty-day exposure of on-site personnel to beta and gamma radiation.
7. Radioactivity in vegetation and soil samples.

C. Off-Site Rad-Safety Data

1. Radioactivity measurements of air.
2. Radioactivity in atmospheric moisture.
3. Radioactivity in Battlement Creek water.
4. Radioactivity in milk, urine, vegetation, and soil.

D. Miscellaneous Data

1. Meteorological records.
2. Chemical analyses of cavity gas.

III. Summary well logs for Project Rulison can be purchased from either of the following two organizations:

Birdwell, a Division
of Seismograph
Service Corporation
6200 East 41 Street
Tulsa, OK 74102

Rocky Mountain Well Log
Service Company
1753 Champa Street
Denver, CO 80202

APPENDIX B

APPENDIX B
RADIOLOGICAL SAFETY GUIDES FOR EXPERIMENTS INVOLVING NUCLEAR EXPLOSIVE STIMULATION OF NATURAL GAS WELLS*

The following guidelines apply to gas stimulation experiments, specifically, Projects Rio Blanco and Wagon Wheel. The site disposal guidelines also apply to Projects Gasbuggy and Rulison. It is recommended that design and operational activities be conducted within these guidelines in such a manner as to reduce the release of radioactive effluents and radiation exposures to personnel, on- and offsite, to the lowest practicable levels. Further, with respect to planned operations and any associated controlled releases, exposures to members of the public should not exceed 10 percent of the limits specified in AEC Appendix 0524. For situations involving inadvertent or accidental releases, various factors including site selection, device design and emplacement, and overall design of the experimental program should be carefully reviewed to ensure that during the lifetime of the project, there will be no significant uncontrolled release of radioactivity off the controlled area.

For the purposes of defining the site-controlled area, the area shall be of such a size and shape that, in the unlikely event there is significant uncontrolled release of radioactivity, an individual located at any point beyond the boundary for two hours immediately following the onset of this postulated release would not receive an estimated total radiation dose to the whole body in excess of 25 rems or an estimated total radiation dose in excess of 300 rems to the thyroid from iodine exposure.

I. GENERAL RADIOLOGICAL CRITERIA

The following radiological safety criteria shall apply during the entire operation period of these projects:

A. For individuals within the controlled area, the radiation protection standards set forth in AEC Appendix 0524, paragraphs I.A. and IV., shall apply.

B. For individuals and population groups in uncontrolled areas, 10 percent of the radiation protection standards set forth in AEC Appendix 0524, paragraph II.A., shall apply. It is noted that the potential for radiation exposure to individuals in the uncontrolled area from planned operations exists only during the time of production testing (flaring) activities.

C. In the unlikely event that an inadvertent release of radioactivity to the uncontrolled area occurs, every effort shall be made to

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*Provided NV by DAT/PNE transmittal letter, this subject, dated April 17, 1972.

reduce potential radiation exposure to individuals offsite to the lowest practicable level. Exposure control guidelines shall be consonant with the principles and levels of protective action guidance provided in Federal Radiation Council Reports 5 and 7.

D. All personal property, i.e., buildings, equipment, and materials, to be removed from the site for uncontrolled use shall meet the criteria specified in Table 1. All personal property, transferred from this site to another location where radiological controls are in effect, shall have the external surfaces of such property meet the criteria specified in Table 1, and be packaged for transport in compliance with AECM 0529.

II. STANDBY CONDITION

The following additional radiological safety criteria shall apply when the operations are to be temporarily interrupted and the site placed in a standby condition, that is, the site is to be left unattended except for periodic surveillance, data collection, and equipment maintenance activities. Methods of disposal of any contaminated personal property, soil, or liquids, to meet this standby criteria, shall be approved by AEC Headquarters. The site shall be fenced to preclude inadvertent access to any remaining equipment, materials, and contaminated land areas. Radiation warning signs are not required if the following criteria are met:

A. Beta-gamma radiation levels in soil shall not exceed 1 mr/hr above background (including worldwide fallout), at 1 centimeter above the surface.

B. Tritium concentrations in soil shall not exceed 3×10^{-2} µCi/g of soil above background (including worldwide fallout).

C. Although no alpha contamination is expected during operations, should such contamination occur, all personal property remaining at the site shall be decontaminated as near as practicable to the criteria specified in Table 1. For soil, the top layer shall not exceed 10,000 dpm/100 cm^2 gross alpha above background (including worldwide fallout).

D. Contaminated liquids remaining at the site shall not exceed the standards provided in AEC Appendix 0524, paragraph II.

III. SITE DISPOSAL

Decontamination and cleanup, prior to release of control and responsibility for the site by the AEC, shall be effected after consideration of the following factors: (1) external radiation levels; (2) migration of radionuclides to man through resuspension in air, movement in water, or passage through food chains; (3) unrestricted property use, immediate and potential; (4) decay and other removal processes tending to reduce potential exposure to man; and (5) the feasibility, cost, and relative effectiveness of further decontamination activities. The cleanup shall be continued until potential future exposures to man are not likely to exceed a few percent of the limits specified in AEC Appendix 0524, paragraph II.A.

Numerical guidance provided herein should not be exceeded without careful consideration of the reasons for doing so. Different values than those provided here may be approved by AEC Headquarters, on a case-by-case basis.

For purposes of planning for disposal of a site for uncontrolled use, the following radiological safety guidance is provided:

A. Surface Waters

Contaminated surface waters in excess of 0.1 times the concentration values listed in AEC Appendix 0524, Annex A, Table 2, Column 2, shall be disposed of by methods approved by AEC Headquarters.

B. Buildings, Equipment, and Materials

Residual radioactive contamination remaining after cleanup operations shall not exceed the levels specified in Table 1.

C. Soil

Residual contaminated soil to a depth of about four feet shall be decontaminated or treated to the extent practicable and any radioactive waste pits exceeding four feet in depth shall be decontaminated to the full depth of the waste in accord with the following criteria:

1. Soil containing residual tritium concentrations exceeding 3×10^{-2} μCi/g of soil shall be excavated for disposition by means approved by AEC Headquarters.

2. Soil containing residual $\beta\gamma$ radiation levels exceeding 0.2 mrad/hr above background (including worldwide fallout) measured at 1 cm shall be excavated for disposition by means approved by AEC Headquarters. After surface restoration, the final average radiation levels shall not exceed 0.05 mrad/hr $\beta\gamma$ above background (including worldwide fallout) measured at 1 cm.

3. Soil gradients shall be examined by suitable sampling and residual contamination shall be removed and disposed of by methods approved by AEC Headquarters when these levels exceed 10^{-2} μCi/g for $\beta\gamma$ decay modes (except tritium) above background (including worldwide fallout). It is not anticipated that radioactivity with an α decay mode will be encountered. If such should be the case, criteria will be provided by AEC Headquarters.

D. A final site survey shall be performed prior to release of the site and copies of a report of the cleanup effort and survey results shall be transmitted to AEC Headquarters/AGMES, AT, BM, WMT, and OS. The report on the site cleanup operation shall include a description of the physical and legal measures taken to prevent deep drilling, mining, or other restrictions on use of the site. Agreements or arrangements for subsequent monitoring should also be described. The certification requirement, associated with this report, is defined in IAD-5301-8, dated February 3, 1972, for all real property and related personal property prior to any disposal or excessing action.

E. Effective site cleanup should eliminate the need for periodic terrestrial and bioenvironmental surveys and only annual surface and groundwater samples should be required for a period of about five years or until there is reasonable assurance that no transport problems exist. Reports of the annual surveys shall be sent to AEC Headquarters/AGMES, AT, BM, WMT, and OS.

TABLE 1

Isotope[2]	Surface Contamination Levels[1] Removable[3]	Total[4] [5]
U-nat, U-235, U-238, Th-nat, Th-232, and associated decay products	1000 dpm or 450 pCi alpha on any 100 cm^2	10,000 dpm or 4500 pCi alpha on any 100 cm^2
Other isotopes which decay by alpha emission or by spontaneous fission	100 dpm or 45 pCi alpha on any 100 cm^2	1000 dpm or 450 pCi alpha on any 100 cm^2
Beta-gamma emitters (isotopes with decay modes other than alpha emission or spontaneous fission)	1000 dpm or 450 pCi beta-gamma on any 100 cm^2	0.4 mrad/hr[6] at 1 cm from the surface

1/ As used in this table, dpm (disintegrations per minute) or pCi (picocurie) means the rate of decay by radioactive material as determined by correcting the counts per minute observed by an appropriate detector and count rate meter, for background, efficiency, and geometric factors associated with the instrumentation and survey procedures.

2/ Where surface contamination by both alpha and beta-gamma emitting isotopes exists, the limits established for alpha and beta-gamma emitting isotopes shall apply independently.

3/ The amount of removable radioactive material on any 100 cm^2 of surface area may be determined by wiping that area with dry filter or soft absorbent paper and with the application of moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known background, efficiency, and geometry. In determining removable contamination on objects of surface area less than 100 cm^2, the pertinent levels shall be reduced proportionately and the entire surface shall be wiped. Alternately, it may be assumed that all of the radioactive material remaining on a surface may be removable, and that amount of radioactive material may be determined by direct measurement with survey instrumentation of sufficient sensitivity to detect levels equivalent to these limits.

4/ Alternatively, for total contamination, one may elect to use an average level one half of that listed in this column, provided that:

(a) The average shall be taken over the total area or 10 square meters, whichever is the lesser; and

(b) At no location shall the maximum exceed 2.5 times the level listed in this column.

5/ It is assumed that measurements of total contamination are made with instruments having a sensitive cross-sectional area of 100 cm^2. Measurements made with instruments having more or less than 100 cm^2 of sensitive area may be related to levels proportionately adjusted, or additional measurements may be made on contiguous areas totaling 100 cm^2 and the findings added for comparison with the specified levels.

6/ Measured through not more than a total of 7 milligrams per square centimeter of absorbing material.

APPENDIX C

TABLE I
Tritium in Rulison Soil Moisture--July 1972

Grid Coordinate[1]	Sampling Depth (in.)[2]	pCi/ml[3]	pCi/g (soil)[4]
N-0, E-2	1	14	0.01
N-0, E-2	12	[5] ND	ND
N-1, E-2	1	3.2	0.007
N-1, E-2	12	14	5.2
N-2, E-2	1	ND	ND
N-2, E-2	12	13	2.9
N-3, E-.7	1	ND	ND
N-3, E-.7	12	5.2	1.1
N-3, E-2	1	ND	ND
N-3, E-2	12	ND	ND
N-4, E-.7	1	3.8	0.4
N-4, E-.7	12	ND	ND
N-4, E-2	1	ND	ND
N-4, E-2	12	ND	ND
N-5, E-.7	1	4.3	0.5
N-5, E-.7	12	4.9	0.95
N-5, E-2	1	ND	ND
N-5, E-2	12	ND	ND
N-6, E-.7	1	ND	ND
N-6, E-.7	12	ND	ND
N-6, E-2	1	290	23
N-6, E-2	12	4.0	0.8
N-7, E-.7	1	ND	ND
N-7, E-.7	12	5.9	2.0
N-7, E-2	1	3.9	0.1
N-7, E-2	12	8.3	1.8
N-8, E-.7	1	ND	ND
N-8, E-.7	12	ND	ND
N-8, E-2	1	ND	ND
N-8, E-2	12	ND	ND
N-9, E-.7	1	ND	ND
N-9, E-.7	12	ND	ND

(1) Cardinal coordinates referenced to entrance gate post-scale: 1 unit equals 10 feet. Radial coordinates are in degrees and feet referenced to flare stack.

(2) Sampling depth increments are 1", i.e., 1" is from 0 to 1", 12" is from 11" to 12", etc.

(3) Concentrations are rounded to two significant figures.

(4) Idem.

(5) Not detected.

TABLE I
Tritium in Rulison Soil Moisture--July 1972
Page 2

Grid Coordinate	Sampling Depth (in.)	pCi/ml	pCi/g (soil)
N-9, E-2	1	33	5.8
N-9, E-2	12	4.2	0.9
N-10, E-.7	1	6.1	0.68
N-10, E-.7	12	ND	ND
N-10, E-2	1	2.8	0.08
N-10, E-2	12	100	24
N-11, E-2	1	190	2.8
N-11, E-2	12	4.1	0.9
N-11.2, E-.2	1	310	25
N-11.2, E-.2	12	38	6.0
N-11.4, E-0	6	2,400	1,300
N-11.8, E-0	24	850	510
N-11.8, E-0	60	7,800	4,400
N-11.9, E-2.8	1	11	2.3
N-11.9, E-2.8	12	33	6.9
N-11.9, E-3.3	1	110	24
N-11.9, E-3.3	12	93	22
N-12, E-.7	1	600	62
N-12, E-.7	12	920	320
N-12, E-2	1	21	1.0
N-12, E-2	12	ND	ND
N-12.5, E-0	1	300	34
N-12.5, E-0	12	120	15
N-12.7, E-0	6	150	81
N-12.7, E-2.8	1	44	10
N-12.7, E-2.8	12	ND	ND
N-12.7, E-3.3	1	21	8.3
N-12.7, E-3.3	12	11	4.7
N-13, E-0	12	73	41
N-13, E-0	60	51	24
N-13, E-.7	1	87	9.3
N-13, E-.7	12	200	49
N-13, E-2	1	51	2.4
N-13, E-2	12	2.9	0.6
N-13, W-3	1	57	27
N-13, W-3	12	13	6.2
N-13.7, E-.1	1	10,000	1,400
N-13.7, E-.1	12	20,000	5,600
N-13.7, E-.1	24	21,000	5,800
N-13.7, E-.6	1	2,700	150
N-13.7, E-.6	12	5,100	1,600
N-13.7, E-.6	24	4,700	1,400
N-14, E-0	1	4,700	1,400
N-14, E-0	12	3,300	1,800
N-14, E-2	1	22	0.3
N-14, E-2	12	3.3	0.7
N-14.2, E-.7	1	8,600	1,500

TABLE I
Tritium in Rulison Soil Moisture--July 1972
Page 3

Grid Coordinate	Sampling Depth (in.)	pCi/ml	pCi/g (soil)
N-14.2, E-.7	12	29,000	6,500
N-14.2, E-.7	24	35,000	11,000
N-14.2, E-.7	36	34,000	19,000
N-14.2, E-.7	48	27,000	7,300
N-14.2, E-.7	60	26,000	14,000
N-14.2, E-.7	72	18,000	9,600
N-14.2, E-.7	96	8,000	4,500
N-14.2, E-.7	108	9,700	2,300
N-14.2, E-.7	120	5,600	1,400
N-14.2, E-.7	132	3,300	600
N-14, W-2	1	110	49
N-14, W-2	12	51	7.7
N-14, W-4	1	16	7.3
N-14, W-4	12	4.4	2.1
N-14.2, E-0	6	3,100	1,700
N-15, E-1	1	650	290
N-15, E-1	12	1,400	670
N-15, E-2	1	300	140
N-15, E-2	12	11	6.0
N-15, W-3	1	420	22
N-15, W-3	12	130	16
N-16, E-1	1	270	120
N-16, E-1	12	260	140
N-16, E-2	1	26	11
N-16, E-2	12	5.3	2.6
N-17, E-1	1	160	75
N-17, E-1	12	17,000	6,000
N-16.7, E-2	1	36	0.9
N-16.7, E-2	12	ND	ND
N-17.8, E-2	1	710	370
N-17.8, E-2	12	330	170
N-18, E-1	1	11	5.3
N-18, E-1	12	80	41
N-19, E-1	1	25	12
N-19, E-1	12	22	11
N-19, E-2	1	10	4.5
N-19, E-2	12	15	7.1
N-20, E-1	1	8.4	3.9
N-20, E-1	12	280	130
N-20, E-2	1	71	34
N-20, E-2	12	10	4.6
N-21, E-1	1	44	20
N-21, E-1	12	73	30
N-21, E-2	1	56	25
N-21, E-2	12	ND	ND

TABLE I
Tritium in Rulison Soil Moisture--July 1972
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Grid Coordinate	Sampling Depth (in.)	pCi/ml	pCi/g (soil)
N-22, E-1	1	25	12
N-22, E-1	12	100	43
N-22, E-2	1	8.4	3.9
N-22, E-2	12	23	12
N-23, E-1	1	15	6.8
N-23, E-1	12	290	140
N-23, E-2	1	6.6	3.2
N-23, E-2	12	3.4	1.7
N-24, E-1	1	59	26
N-24, E-1	12	69	33
N-24, E-2	1	450	220
N-24, E-2	12	6.9	3.6
N-24, W-2	72	14	2.1
N-25, E-1	1	16	7.1
N-25, E-1	12	15	7.3
N-25, E-2	1	18	8.7
N-25, E-2	12	22	11
N-26, E-1	1	15	6.4
N-26, E-1	12	39	19
N-26, E-2	1	31	14
N-26, E-2	12	34	17
N-27, E-1	1	44	23
N-27, E-1	12	51	24
N-28, E-1	1	390	180
N-28, E-1	12	160	86
000°, 20'	1	180	44
000°, 20'	12	290	94
000°, 40'	1	43	3.2
000°, 40'	12	14	1.1
030°, 20'	1	32	8.5
030°, 20'	12	53	18
030°, 40'	1	22	1.1
030°, 40'	12	ND	ND
060°, 20'	1	10	3.5
060°, 20'	12	14	4.3
060°, 40'	1	100	12
060°, 40'	12	11	0.75
090°, 20'	1	84	4.9
090°, 20'	12	27	8.6
090°, 40'	1	32	3.0
090°, 40'	12	4.8	0.55
120°, 20'	1	74	7.3
120°, 20'	12	45	6.0
120°, 20'	24	290	40
120°, 20'	48	81	42
120°, 40'	1	18	2.0
120°, 40'	12	15	1.4

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Tritium in Rulison Soil Moisture--July 1972
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Grid Coordinate	Sampling Depth (in.)	pCi/ml	pCi/g (soil)
120°, 40'	24	140	28
120°, 40'	48	380	73
120°, 60'	1	60	8.4
120°, 60'	12	27	3.6
120°, 60'	24	290	160
120°, 60'	48	290	61
150°, 20'	1	28	2.3
150°, 20'	12	3.6	0.6
150°, 40'	1	37	5.4
150°, 40'	12	21	3.1
210°, 20'	1	170	7.1
210°, 20'	12	220	48
210°, 40'	1	11	0.46
210°, 40'	12	ND	ND
240°, 20'	1	1,100	82
240°, 20'	12	4,700	1,400
240°, 40'	1	60	7.6
240°, 40'	12	16	2.0
270°, 20'	1	16	5.3
270°, 20'	12	53	17
270°, 40'	1	22	0.93
270°, 40'	12	ND	ND
300°, 3'	1	230	100
300°, 3'	12	780	400
300°, 3'	24	3,300	1,900
300°, 3'	36	3,800	820
300°, 3'	48	5,700	1,300
300°, 3'	60	6,400	3,200
300°, 3'	72	4,400	2,500
300°, 3'	84	2,900	1,400
300°, 3'	96	2,700	1,300
300°, 20'	1	400	115
300°, 20'	12	450	150
300°, 20'	24	3,900	520
300°, 20'	48	2,500	520
300°, 40'	1	42	2.1
300°, 40'	12	8.6	1.2
330°, 20'	1	350	100
330°, 20'	12	600	180
330°, 40'	1	65	4.1
330°, 40'	12	17	1.5
S-1, E-1	1	6.5	0.04
S-1, E-1	12	ND	ND
S-1, E-2	1	10	0.006
S-1, E-2	12	ND	ND

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Tritium in Rulison Soil Moisture--July 1972
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Grid Coordinate	Sampling Depth (in.)	pCi/ml	pCi/g (soil)
S-1, E-3	1	ND	ND
S-1, E-3	12	ND	ND
S-2, W-.7	1	ND	ND
S-2, W-.7	12	7.3	1.2
S-3, E-0	1	1,500	810
S-3, E-0	12	66	11
S-3, E-2	1	ND	ND
S-3, E-2	12	ND	ND
S-3.8, E-1.4	1	ND	ND
S-3.8, E-1.4	12	ND	ND
S-5, E-0	1	ND	ND
S-5, E-0	12	ND	ND
S-5, E-2	1	ND	ND
S-5, E-2	12	ND	ND
S-5, E-4	1	ND	ND
S-5, E-4	12	20	3.4
S-5.7, W-2	1	200	7.5
S-5.7, W-2	12	2.9	0.56
S-7, E-0	1	ND	ND
S-7, E-0	12	ND	ND
S-7, E-2	1	ND	ND
S-7, E-2	12	ND	ND
S-7, E-4	1	ND	ND
S-7, E-4	12	ND	ND
S-7, E-6	1	70	29
S-7, E-6	12	ND	ND
S-7, E-8	1	770	13
S-7, E-8	12	ND	ND
S-7, E-10	1	91	2.3
S-7, E-10	12	ND	ND
S-7, E-12	1	6.7	0.17
S-7, E-12	12	ND	ND
S-7.5, W-2.7	1	43	0.37
S-7.5, W-2.7	12	ND	ND
S-8, W-1.5	1	ND	ND
S-8, W-1.5	12	ND	ND
S-9, E-0	1	ND	ND
S-9, E-0	12	ND	ND
S-9, E-2	1	100	41
S-9, E-2	12	ND	ND
S-9, E-4	1	ND	ND
S-9, E-4	12	ND	ND
S-9, E-6	1	ND	ND
S-9, E-6	12	ND	ND
S-9, E-8	1	ND	ND
S-9, E-8	12	ND	ND

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Tritium in Rulison Soil Moisture--July 1972
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Grid Coordinate	Sampling Depth (in.)	pCi/ml	pCi/g (soil)
S-9, E-10	1	130	4.5
S-9, E-10	12	ND	ND
S-9, E-12	1	110	2.1
S-9, E-12	12	ND	ND
S-9.4, W-3.4	1	3,900	32
S-9.4, W-3.4	12	230	25
S-10, W-1.5	1	ND	ND
S-10, W-1.5	12	ND	ND
S-10.3, E-10.1	1	ND	ND
S-10.3, E-10.1	12	ND	ND
S-10.3, E-10.1	24	ND	ND
S-10.3, E-10.1	48	ND	ND
S-11, E-0	1	610	11
S-11, E-0	12	ND	ND
S-11, E-2	1	ND	ND
S-11, E-2	12	ND	ND
S-11, E-4	1	62	0.98
S-11, E-4	12	ND	ND
S-11, E-6	1	ND	ND
S-11, E-6	12	ND	ND
S-11, E-8	1	ND	ND
S-11, E-8	12	ND	ND
S-11, E-10	1	ND	ND
S-11, E-10	12	ND	ND
S-11, E-12	1	ND	ND
S-11, E-12	12	ND	ND
S-11, E-14	1	ND	ND
S-11, E-14	12	ND	ND
S-11.2, W-4	1	280	21
S-11.2, W-4	12	ND	ND
S-11.7, E-3.1	1	ND	ND
S-11.7, E-3.1	12	ND	ND
S-11.7, E-8.7	1	ND	ND
S-11.7, E-8.7	12	ND	ND
S-11.7, E-8.7	24	ND	ND
S-11.7, E-8.7	48	ND	ND
S-12, E-1	1	ND	ND
S-12, E-1	12	ND	ND
S-12, E-5	1	18	0.2
S-12, E-5	12	ND	ND
S-12, W-1.5	1	3.8	0.2
S-12, W-1.5	12	ND	ND
S-12.4, E-3.8	1	ND	ND
S-12.4, E-3.8	12	ND	ND
S-12.8, E-1.9	1	ND	ND
S-12.8, E-1.9	12	ND	ND

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Tritium in Rulison Soil Moisture--July 1972
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Grid Coordinate	Sampling Depth (in.)	pCi/ml	pCi/g (soil)
S-12.8, E-1.9	24	ND	ND
S-12.8, E-1.9	48	ND	ND
S-13, E-0	1	ND	ND
S-13, E-0	12	ND	ND
S-13, E-6	1	ND	ND
S-13, E-6	12	ND	ND
S-13, E-8	1	14	0.32
S-13, E-8	12	84	6.3
S-13, E-10	1	11	0.01
S-13, E-10	12	ND	ND
S-13, E-12	1	ND	ND
S-13, E-12	12	ND	ND
S-13, E-14	1	ND	ND
S-13, E-14	12	ND	ND
S-13.1, E-7.3	1	ND	ND
S-13.1, E-7.3	12	ND	ND
S-13.1, E-7.3	24	ND	ND
S-13.1, E-7.3	48	ND	ND
S-13.1, W-4.8	1	690	290
S-13.1, W-4.8	12	ND	ND
S-13.2, E-4.5	1	ND	ND
S-13.2, E-4.5	12	ND	ND
S-13.5, E-2.8	1	ND	ND
S-13.5, E-2.8	12	ND	ND
S-13.9, E-5.2	1	ND	ND
S-13.9, E-5.2	12	ND	ND
S-14, E-.8	1	ND	ND
S-14, E-.8	12	ND	ND
S-14, W-3.4	1	120	1.1
S-14, W-3.4	12	45	8.5
S-14.2, E-3.4	1	ND	ND
S-14.2, E-3.4	12	12	1.6
S-14.2, E-3.4	24	ND	ND
S-14.2, E-3.4	48	ND	ND
S-14.6, E-5.9	1	20	0.1
S-14.6, E-5.9	12	ND	ND
S-14.6, E-5.9	24	ND	ND
S-14.6, E-5.9	48	ND	ND
S-14.7, E-1.6	1	ND	ND
S-14.7, E-1.6	12	ND	ND
S-15, E-12	1	26	0.03
S-15, E-12	12	ND	ND
S-15, E-14	1	ND	ND
S-15, E-14	12	ND	ND
S-15, W-1.8	1	76	1.4
S-15, W-1.8	12	1,400	210

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Tritium in Rulison Soil Moisture--July 1972
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Grid Coordinate	Sampling Depth (in.)	pCi/ml	pCi/g (soil)
S-15.4, E-2.2	1	ND	ND
S-15.4, E-2.2	12	ND	ND
S-15.4, E-5	1	55	0.4
S-15.4, E-5	12	ND	ND
S-15.4, E-5	24	ND	ND
S-15.4, E-5	48	ND	ND
S-15.4, E-6.6	1	480	7.6
S-15.4, E-6.6	12	ND	ND
S-15.4, E-8	1	ND	ND
S-15.4, E-8	12	12	2.1
S-16, E-0	1	ND	ND
S-16, E-0	12	ND	ND
S-16.1, E-3	1	520	16
S-16.1, E-3	12	ND	ND
S-16.2, E-4	1	48	1.3
S-16.2, E-4	12	ND	ND
S-16.2, E-4	24	ND	ND
S-16.2, E-4	48	ND	ND
S-16.6, E-6.6	1	8.5	0.2
S-16.6, E-6.6	12	5.3	0.5
S-16.6, E-6.6	24	8.9	0.9
S-16.6, E-6.6	48	ND	ND
S-16.6, E-8	1	5.9	0.24
S-16.6, E-8	12	5.7	0.3
S-17, E-10	1	ND	ND
S-17, E-10	12	ND	ND
S-17, E-12	1	ND	ND
S-17, E-12	12	46	2.4
S-17, E-14	1	190	54
S-17, E-14	12	ND	ND
S-17.1, E-1.8	1	89	1.2
S-17.1, E-1.8	12	ND	ND
S-18, E-6.5	1	11	0.1
S-18, E-6.5	12	14	1.3
S-18.2, E-3.5	1	270	56
S-18.2, E-3.5	12	ND	ND
S-19, E-8	1	11	0.67
S-19, E-8	12	ND	ND
S-19, E-9	1	ND	ND
S-19, E-9	12	ND	ND
S-19, E-9	24	ND	ND
S-19, E-9	48	ND	ND
S-19, E-10	1	ND	ND
S-19, E-10	12	50	4.9
S-19, E-12	1	ND	ND
S-19, E-12	12	5.8	0.28

TABLE I
Tritium in Rulison Soil Moisture--July 1972
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Grid Coordinate	Sampling Depth (in.)	pCi/ml	pCi/g (soil)
S-19, E-14	1	ND	ND
S-19, E-14	12	ND	ND
S-19.3, E-5.1	1	58	1.4
S-19.3, E-5.1	12	11	2.3
S-20, E-12	1	12	0.56
S-20, E-12	12	15	0.39
S-20.4, E-6.8	1	ND	ND
S-20.4, E-6.8	12	ND	ND
S-21, E-14	1	19	0.43
S-21, E-14	12	ND	ND
S-21.5, E-8.5	1	300	2.2
S-21.5, E-8.5	12	ND	ND
S-22.5, E-10.2	1	130	0.52
S-22.5, E-10.2	12	ND	ND
S-23.2, E-17	1	9.4	4.1
S-23.2, E-17	12	ND	ND
S-23.5, E-12	1	13	0.54
S-23.5, E-12	12	4.1	0.71
S-23.8, E-15.3	1	32	1.2
S-23.8, E-15.3	12	ND	ND
S-24.6, E-13.7	1	47,000	20,000
S-24.6, E-13.7	12	860	140
S-24.6, E-17	1	36	0.39
S-24.6, E-17	12	19	3.2
S-25.4, E-15.4	1	1,400	22
S-25.4, E-15.4	12	1,700	235

TABLE 2

Tritium in Rulison Soil Moisture
Postproduction Test--April 23, 1971

Grid Coordinate(1)	Sampling Depth (in.)(4)	pCi/ml(2)	pCi/g (soil)(3)
000°, 20'	1	390	100
000°, 20'	3	980	250
000°, 20'	6	480	120
000°, 20'	0 to 2	940	250
000°, 20'	2 to 4	540	130
000°, 20'	4 to 6	260	68
000°, 20'	6 to 8	220	55
000°, 20'	8 to 10	260	62
000°, 20'	10 to 12	210	50
000°, 40'	1	1,700	420
000°, 40'	0 to 2	400	94
000°, 40'	2 to 4	510	120
000°, 40'	4 to 6	750	180
000°, 40'	6 to 8	660	150
000°, 40'	8 to 10	580	130
000°, 40'	10 to 12	510	110
000°, 80'	1	180	44
000°, 80'	0 to 2	350	88
000°, 80'	2 to 4	510	110
000°, 80'	4 to 6	500	100
000°, 80'	6 to 8	370	88
000°, 80'	8 to 10	280	57
000°, 80'	10 to 12	210	46
000°, 120'	1	650	230
000°, 120'	0 to 2	410	110
000°, 120'	2 to 4	340	71
000°, 120'	4 to 6	290	68
000°, 120'	6 to 8	320	76
000°, 120'	8 to 10	250	62
000°, 120'	10 to 12	210	49
000°, 200'	1	130	43
000°, 500'	1	39	9.8
000°, 500'	6	20	3.4
000°, 1000'	1	19	4.1

(1) Radial coordinates are in degrees and feet referenced to flare stack.

(2) Concentrations are rounded to two significant figures.

(3) Idem.

(4) Sampling depth increments, when not otherwise indicated, are 1", i.e., 1" is from 0 to 1", 6" is from 5" to 6", etc.

TABLE 2
Tritium in Rulison Soil Moisture
Postproduction Test--April 23, 1971
Page 2

Grid Coordinate	Sampling Depth (in.)	pCi/ml	pCi/g (soil)
000°, 1000'	6	12	2.7
030°, 20'	1	510	130
030°, 40'	1	140	34
030°, 200'	1	79	18
030°, 80'	1	97	23
030°, 120'	1	180	42
060°, 20'	1	760	210
060°, 40'	1	300	80
060°, 80'	1	120	20
060°, 120'	1	300	120
060°, 200'	1	70	24
090°, 20'	1	300	76
090°, 40'	1	160	44
090°, 80'	1	130	36
090°, 120'	1	260	82
090°, 200'	1	46	16
090°, 500'	1	2,400	630
090°, 500'	6	53	14
090°, 1000'	1	11	3.2
090°, 1000'	6	13	3.3
120°, 20'	1	3,800	970
120°, 40'	1	2,100	550
120°, 80'	1	1,400	370
120°, 120'	1	190	56
120°, 200'	1	380	55
150°, 20'	1	130	29
150°, 40'	1	710	160
150°, 80'	1	200	54
150°, 120'	0 to 1	210	65
150°, 120'	1 to 2	180	53
150°, 120'	2 to 4	220	62
150°, 120'	4 to 8	290	87
150°, 120'	8 to 12	420	110
150°, 120'	12 to 16	340	84
150°, 120'	16 to 20	130	25
150°, 120'	20 to 24	79	16
150°, 120'	24 to 28	75	15
150°, 120'	28 to 32	110	19
150°, 120'	32 to 36	110	22
150°, 120'	36 to 40	87	19
150°, 120'	40 to 44	62	14
150°, 120'	44 to 48	59	13
150°, 200'	1	190	34
180°, 5'	1	7,400	1,600
180°, 5'	6	3,000	700

TABLE 2
Tritium in Rulison Soil Moisture
Postproduction Test--April 23, 1971
Page 3

Grid Coordinate	Sampling Depth (in.)	pCi/ml	pCi/g (soil)
180°, 20'	1	2,800	620
180°, 40'	1	170	33
180°, 80'	1	410	85
180°, 120'	1	1,500	300
180°, 200'	1	79	8.7
180°, 500'	1	1,900	650
180°, 500'	6	6	1.1
180°, 1000'	1	57	14
180°, 1000'	6	6	1.2
210°, 20'	1	540	130
210°, 40'	1	240	50
210°, 80'	1	110	33
210°, 120'	1	100	23
210°, 200'	1	84	10
240°, 14'	1	2,800	730
240°, 20'	1	680	180
240°, 40'	1	270	62
240°, 80'	1	130	28
240°, 120'	1	34	7
240°, 200'	1	77	8.1
270°, 20'	1	1,600	410
270°, 40'	1	240	68
270°, 80'	1	240	60
270°, 120'	1	230	53
270°, 200'	1	37	10
270°, 500'	1	8	1.2
270°, 500'	6	26	5.8
270°, 1000'	1	12	2.6
270°, 1000'	6	27	5.6
300°, 20'	1	1,200	310
300°, 40'	1	200	54
300°, 80'	1	340	76
300°, 120'	1	88	21
300°, 200'	1	140	32
330°, 20'	1	1,900	500
330°, 20'	3	5,700	1,400
330°, 20'	6	6,800	1,600
330°, 20'	1	1,400	350
330°, 20'	2	790	200
330°, 20'	2 to 4	1,900	480
330°, 20'	4 to 8	4,500	1,100
330°, 20'	8 to 12	3,800	900
330°, 20'	12 to 16	3,100	710
330°, 20'	16 to 24	1,900	440

TABLE 2
Tritium in Rulison Soil Moisture
Postproduction Test--April 23, 1971
Page 4

Grid Coordinate	Sampling Depth (in.)	pCi/ml	pCi/g (soil)
330°, 20'	24 to 28	860	200
330°, 20'	28 to 32	190	43
330°, 20'	32 to 36	250	57
330°, 20'	36 to 40	40	8.1
330°, 20'	40 to 44	280	60
330°, 20'	44 to 48	250	47
330°, 40'	1	160	44
330°, 80'	1	230	56
330°, 120'	1	270	76
330°, 200'	1	210	60

TABLE 3

Tritium in Vegetation--July 1972

Sampling Point (referenced to flare stack)	Dry/Wet Ratio	Unbound(1)		Bound(2)		Total
		pCi/ml (H_2O)	pCi/g (wet)	pCi/ml (H_2O) (water from oxidation)	pCi/g (wet)	pCi/g (wet)
000°, 500'	0.38	7.0	4.3	< 31	<1.7	≃ 4.3
000°, 1000'	0.42	7.2	2.8	< 8.3	<1.4	≃ 2.8
090°, 500'	0.23	4.5	3.5	< 32	<1.5	≃ 3.5
090°, 1000'	0.30	8.1	5.7	< 33	<1.1	≃ 5.7
180°, 500'	0.22	75	58	< 16	<0.9	≃ 58
180°, 1000'	0.25	7.1	5.3	< 11	<0.8	≃ 5.3
270°, 500'	0.19	5.5	4.5	< 28	<0.8	≃ 4.5
270°, 1000'	0.25	7.5	5.6	< 14	<1.0	≃ 5.6
030°, 5'	0.13	170	150	190	5.3	160
120°, 40'	0.27	64	47	97	3.6	51
*N-14, W-2	0.22	150	120	41	2.3	120

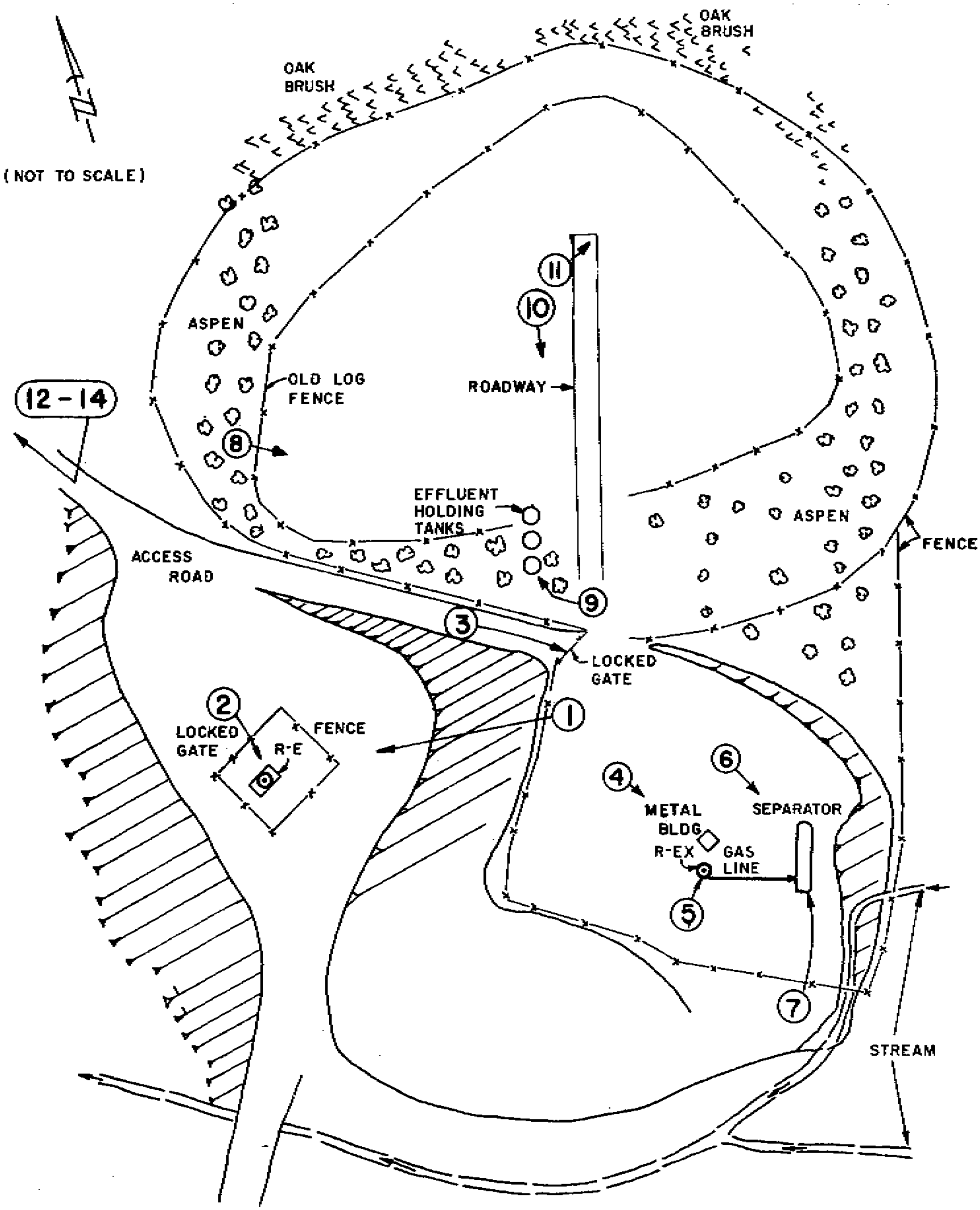
*West of tank 3, referenced to entrance gate post.

(1) Unbound is tritium in water that was removable by drying the sample in an electric oven for 16 hours.

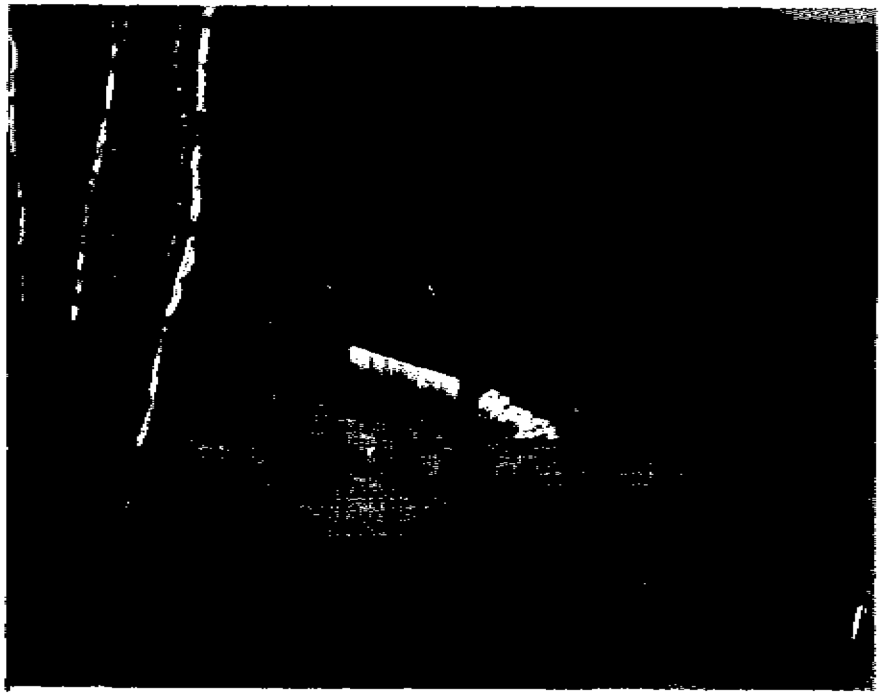
(2) Bound is tritium converted to water form by oxidizing the dried sample.

APPENDIX D

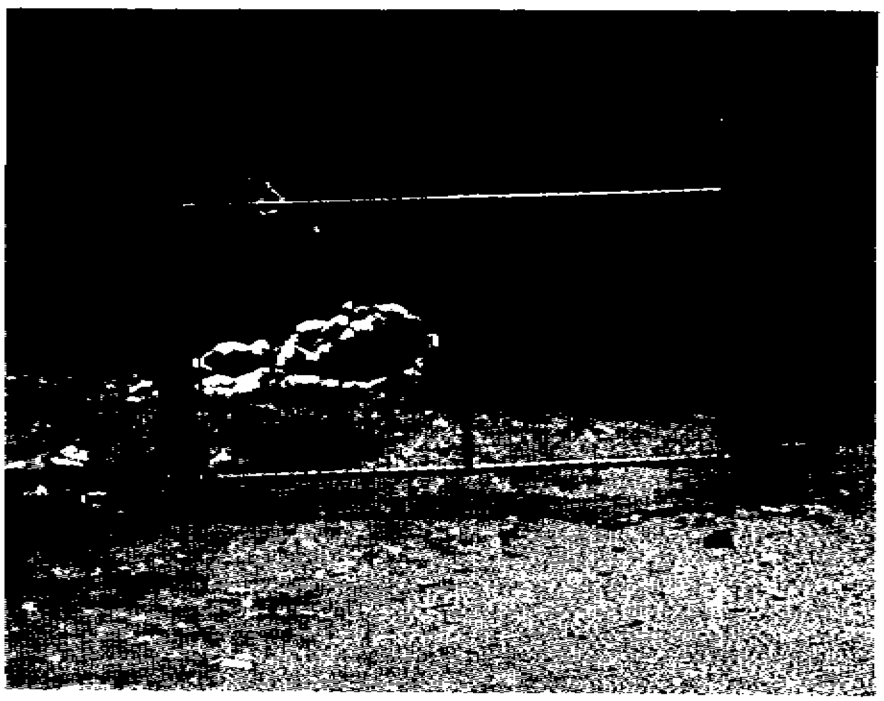
COLLECTION OF DOCUMENTARY PHOTOGRAPHS OF RULISON SITE



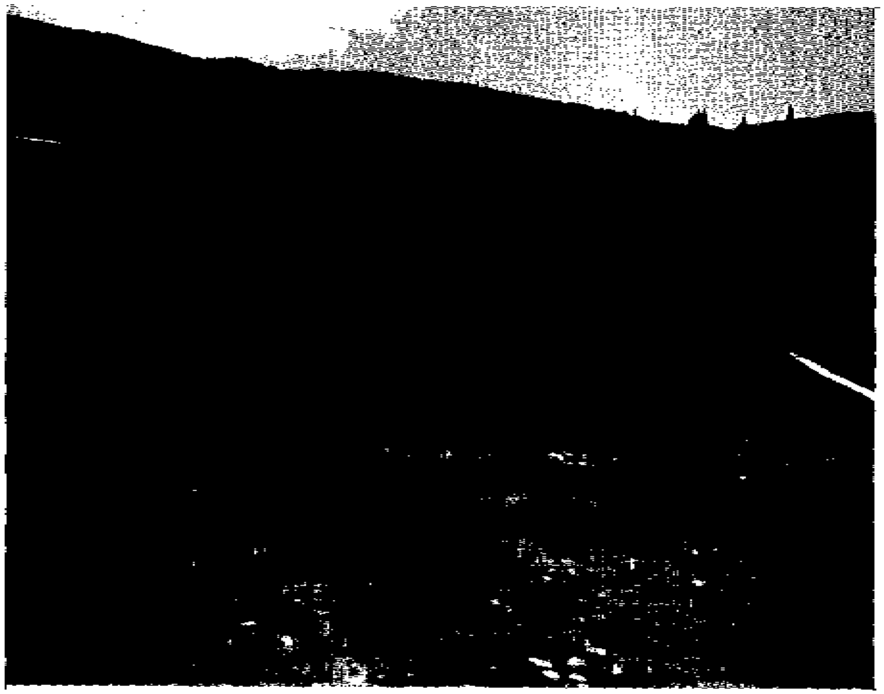
CIRCLED FIGURES SHOW LOCATION AND BEARING OF PHOTOGRAPH.



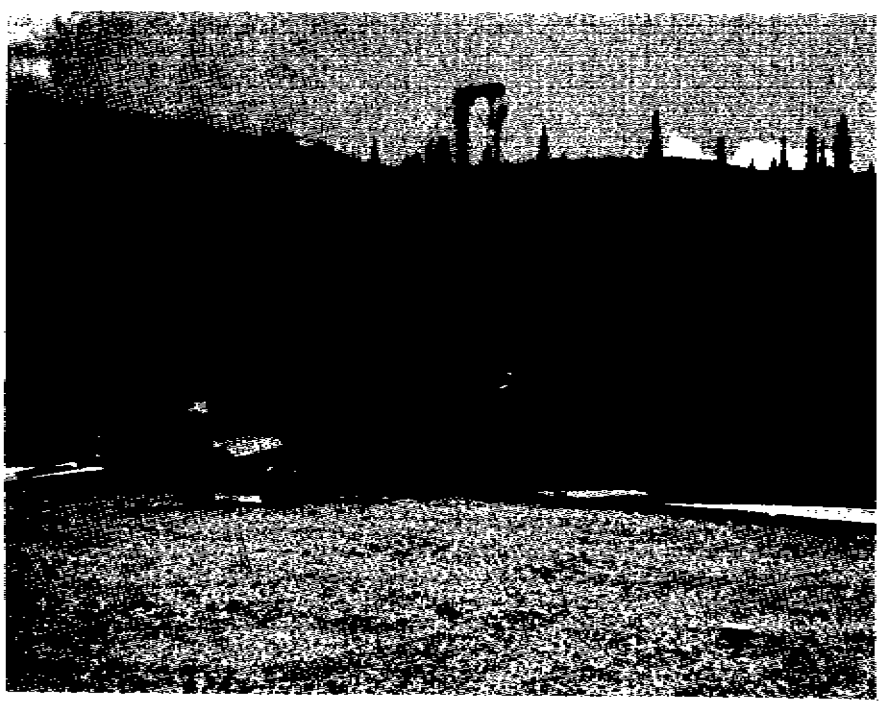
(1) LOOKING DOWN AND WEST FROM THE R-EX DRILL PAD AT THE R-E SHACK AND PROTECTIVE FENCE.



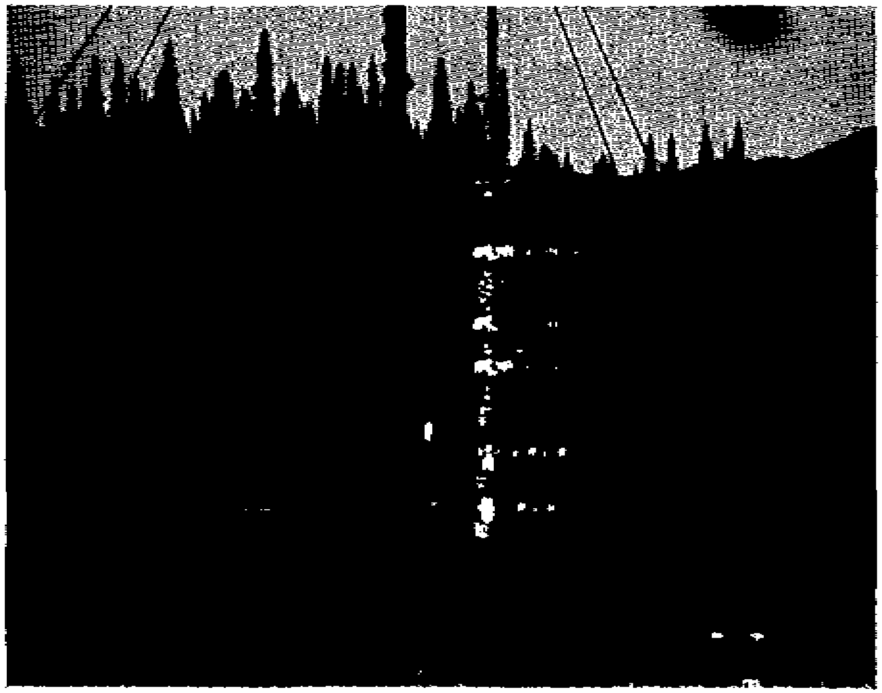
(2) CLOSE-UP OF R-E SHACK, PROTECTIVE FENCE AND LOCKED GATE. (LOOKING SOUTHEAST)



(3) LOOKING SOUTHEAST AT LOCKED GATE AND WARNING SIGN AT R-EX DRILL PAD.



(4) LOOKING SOUTHEAST AT R-EX CHRISTMAS TREE AND REMAINING FACILITIES.

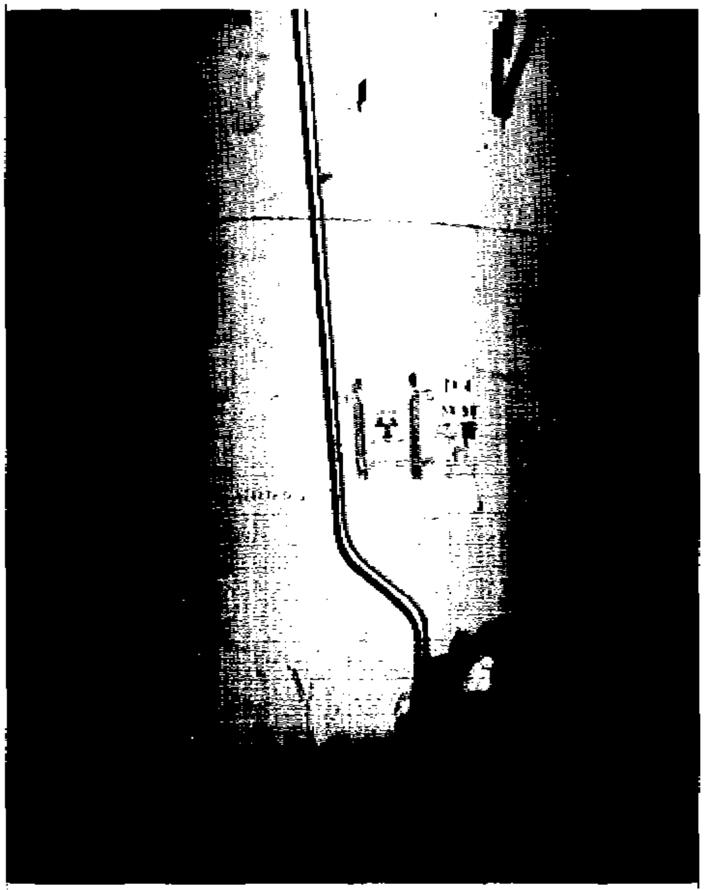


(5) CLOSE-UP OF R-EX CHRISTMAS TREE AND SURROUNDING DRIP PANS. (LOOKING EAST)

(6) VIEW OF SEPARATOR AND CONNECTING GAS LINE (LOOKING SOUTH)

(7) LOOKING NORTHEAST AT PERIMETER FENCE AND WARNING SIGN (HYDROCARBON SEPARATOR IN BACKGROUND)

(8) LOOKING SOUTHEAST AT AT PERIMETER FENCE (THE THREE EFFLUENT TANKS IN BACKGROUND)



(9) CLOSE UP OF EFFLUENT HOLDING TANK SHOWING LOCKED CAP ON DRAIN LINE. VALVE

(10) EFFLUENT HOLDING TANKS FROM THE NORTHEAST (R-EX DRILLING PAD IN RIGHT BACKGROUND)

(11) SITE OF THE FLARE STACK REMOVED DURING CLEAN-UP (LOOKING NORTHEAST)

(12) OLD DRILLING PIT, PROTECTIVE FENCE AND LOCKED GATE. (LOOKING WEST)

(13) DRILLING PIT SPILLWAY LOOKING NORTHWEST
(NOTE RECOLONIZATION BY NATIVE PLANTS)

(14) BERM AT WESTERN END OF THE DRILLING PIT
INSIDE FENCE (LOOKING SOUTH)